Aalto University
School of Business

# ASSOCIATION OF EU ETS, EARNINGS AND EMPLOYMENT IN MANUFACTURING IN FINLAND

## An empirical event study of earnings and employment of individual employees at installation-level between 2000-2016

Master's Thesis
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**Abstract of master's thesis**

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**Abstract**

We have investigated how EU emission trading scheme (EU ETS) has associated to the development of earnings of individual employees who have worked in regulated manufacturing factors in Finland when the policy started in 2005. Their earnings are compared to earnings of individuals, who worked in same sectors, but in smaller installations that were not regulated by the policy. The follow-up of individuals between 2000-2016 shows that the workers in EU ETS sectors had on average EUR 5 000 higher annual earnings compared to the control group before the policy started and this difference was diminished by an average EUR 2 800 after the policy started.

It seems that this decrease is due to lower employment rate. The treatment group had more than 4 percent unit lower employment rate compared to the control group, which in 2016 translates into 7.5 % lower employment. The earnings of those who were employed decreased by EUR 2 300 when the policy started, but otherwise the employed employees had EUR 5 000 higher earnings compared to the control group also after the policy started. Our set-up doesn't allow a full causal interpretation that the decrease if fully influenced by the policy, as different industrial sectors are disproportionally represented in the treatment and control group.

The previous literature has shown 2 percent decrease in employment and no effect on wages at company-level. At installation-level the effect on employment has been a 7 % decrease, which is in line with our result. We have used individual-based data on annual earnings, which have included information of working station, which was matched to the information of installations' participation to the policy. As participation to EU ETS is determined at installation-level, our set-up allows more precise results than those conducted at company-level.

The result seems to support pollution haven -hypothesis, which states that the policy makes regulated entities less competitive due to increased costs, and therefore production or market shares are outsourced to regions with laxer environmental policies.

**Keywords** EU ETS, earnings, employment, empirical, ex post

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Olemme tarkastelleet EU:n päästökaupan (EU ETS) yhteyttä säännösteltyjen teollisuuslaitosten työntekijöiden ansiotuloihin Suomessa päästökaupan alettua vuonna 2005. Säännöstellyissä laitoksissa päästökaupan alun hetkellä työskennelleiden työntekijöiden ansiotulojen kehitystä on verrattu sellaisten työntekijöiden ansiotuloihin, jotka työskentelivät samaan aikaan vastaavien teollisuusalojen laitoksissa, mutta eivät kuuluneet päästökauppaan pienen kapasiteettinsa takia. Ansiotulojen seuranta vuosina 2000-2016 näyttää, että reguloitujen laitosten työntekijöiden vuosiansiotulot olivat keskimäärin 5 000 euroa suuremmat ennen päästökaupan alkua, mutta palkkaero laski keskimäärin 2 800 eurolla päästökaupan alettua.

Keskimääräisten ansiotulojen lasku näyttää johtuvan matalammasta työllisyysasteesta. Säännösteltyjen laitosten työntekijöiden työllisyysaste oli yli 4 prosenttiyksikköä verrokkeja matalampi, mikä vuonna 2016 tarkoitti 7.5 % matalampaa työllisyyttä. Työssäkäyvien ansiotulot laskivat 2 300 eurolla heti päästökaupan alkamisen jälkeen verrokkeihin nähden, mutta muutoin työssäkäyvät säilyttävät 5000 euron ansiotuloeron myös päästökaupan alettua. Tutkimusasetelmamme ei takaa, että kyseessä olisi juuri päästökaupan aiheuttama lasku, sillä eri teollisuusalat ovat epäsuhdasti edustettu koe- ja verrokkiryhmässä. Tulos antaa suuntaa-antavan lähtökohdan tarkemmalle syy-seurausanalyysille päästökaupan vaikutuksista työllisyyteen ja ansiotuloihin.

Aiemmissa tutkimuksissa EU:n päästökaupalla on havaittu 2 prosentin negatiivinen vaikutus työllisyyteen yritystasolla, mutta ei vaikutusta palkkoihin. Laitoskohtaisessa tarkastelussa työllisyysvaikutus oli haivaittu olevan 7 %, mikä vastaa havaintoamme. Olemme käyttäneet dataa yksilöiden ansiotulojen ja työllisyyden kehityksestä, jossa on ollut mukana tieto toimipaikasta, joka on pystytty yhdistämään tietoon laitosten päästökauppaan kuulumisesta. Koska EU:n päästökauppaan kuuluminen määritellään laitoskohtaisesti, tutkimusasetelmamme takaa yritystasolla tehtyjä tarkasteluja tarkemmat tulokset yksilöiden näkökulmasta.

Tuloksemme näyttäisi viittaavan ns. pollution haven -hypoteesiin (päästöjen turvasatamahypoteesi), jonka mukaan päästökaupan kustannukset heikentävät yritysten kilpailukykyä, ja näin ollen tuotanto tai markkinaosuudet siirtyvät vähemmän säännöstellyille aluille.

**Avainsanat** Päästökauppa, EU ETS, ansiotulot, työllisyys, empiirinen, ex post

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# 1 INTRODUCTION

The objective of this thesis is to study the potential effect of EU’s Emission Trading Scheme (EU ETS) on the earnings of the employees, who have worked in regulated manufacturing installations. Installations mean manufacturing factories. EU ETS is an emission reduction policy, which has set an absolute and yearly declining maximum amount of emissions within its area for the regulated sectors. The cap is divided into allowances, which installations must surrender for their verified emissions. Installations have received allowances also for free, but if their emission exceeds this limit, they must acquire allowances from auctions or from other participants from secondary markets.

As the policy imposes costs to the companies, the producer can pass-through the cost to the end-consumers if the demand is inelastic to changes in price. If the market price is fixed due to international competition, the producer must bear the cost of the policy and either decrease the whole production to match the market price to the marginal cost. Either the cost falls to the most flexible part of the production, supply of labour as one factor.

In this study, the earnings of individual employees are drawn from combined employer-employee dataset from Statistics Finland. The Finnish Longitudinal Employer–Employee Data (FLEED) includes information of annual earnings of Finnish working-age residents and their working station. The working stations of employees are matched to information from the data of energy use in manufacturing sectors produced by Statistics Finland, which included information of installations participation to the policy. The earnings of employees who worked in installation when the policy started in 2005 are compared to the earnings of employees who worked in same industries, but in non-regulated and therefore smaller installations.

The number of ex-post empirical studies on the effect of EU ETS is somewhat limited, as data comes with a delay and a credible control group is difficult to form in an EU-wide policy. Previous study at company-level had found no effect on wages and a 2 % decrease in employment when the policy started (Marin, Marino and Pellegrin, 2018). Although the policy has been successful to reduce the emission within the sectors, the negative impact seems to be limited in the light of the relevant literature on the issue.

On general level, the policy could lead to three different kind of outcome: pollution haven hypothesis, Porter hypothesis or zero effect. Firstly, pollution haven hypothesis presumes the competitiveness of the regulated companies would decline because of increased costs. This would be detected as negative effect on aggregate earnings, as employment would decrease as production would decrease. Secondly, Porter hypothesis states that regulation induces innovation and gives a first mover advantage improving competitiveness as companies become more aware of their use of resources (Porter & van der Linde, 1995). This could be detected as positive effect on earnings, as employment would be in demand and this would reflect as an upward pressure on wages. Thirdly, zero effect could be that the costs of the policy have been so minor for the companies that there is no significant change in employment or earnings.

Our empirical results show that the aggregated average earnings of employees in regulated installations have decreased compared to their controls. A lower employment seems to drive this difference. A causal relationship would need more delicate identification strategy, but this result indicates that the pollution haven hypothesis seems strongest to hold in the light of the first 10 years of the policy in force.

## 1.1 Research objectives

The research objective is to study whether EU's Emission Trading Scheme (EU ETS) has affected employees' earnings and employment in installation that are regulated by EU ETS policy. EU ETS covers only large installations, which belong to heavy-emitting industries and have above threshold maximum production capacity. Otherwise similar installations in same industries but below the thresholds are not part of emission trading. We use this threshold determination as our identification strategy.

We use data of yearly earnings of employees from Statistics Finland, who work in installations just above and just below the capacity thresholds. We try to identify whether EU ETS has had impact on employees' earnings in Finland. We use panel data OLS-regression to analyse the difference in the development of these two groups to identify the treatment effect.

### 1.2 Structure of the thesis

Firstly, in chapter two we introduce to the EU Emission Trading Scheme (EU ETS): basic elements of it, how and when it was developed. Then we compare emission reduction to EU ETS targets. We also look at the emissions associated with consumption to reflect whether emissions are outsourced to other areas.

In chapter three we introduce how the costs of the policy could affect the manufacturing supply by passing-through the costs to end-consumers or bearing them within the production. Employees are affected if increased costs lead to reduction in production or that costs are saved using the flexibility of the supply of labour. We put in proportion the costs of the policy and personnel costs compared to other operative costs of regulated companies using Neste and Outokumpu's steel factory as examples.

In chapter four, the literature review summaries the results and set-ups of empirical papers that have studied the effect of EU ETS on competitiveness, innovation, employment and wages.

In chapter five we introduce in more detail the data, empirical set-up and descriptive statistics of the treatment and control group. In chapter six we introduce the findings and caveats of the study. In chapter seven we conclude the main results, their practical implications and suggestions for further research.

## 2 EU EMISSION TRADING SCHEME

Decision-makers in Europe concerned of the carbon dioxide influenced climate change in early 1990's and wanted to find a cost-efficient solution to steer production or consumption away from growing path of greenhouse gas emissions. EU's decision makers came up with an EU-wide, market-based solution, which they launched in five years from idea to EU-wide legislation. The cap and number of emission allowances was set generously, equalling or even exceeding current demand of the member states at a time, making the policy politically implementable. The impact on international competitiveness and carbon leakage has been a concern.

A policy that includes the externalities of the emissions as costs for the producers was needed. Lyubich, Shapiro and Walker (2018) studied heterogeneity in energy and $CO_2$

productivity for US manufacturing sector in 2006 and 2007. They counted the average dollars of output per dollar of energy input or per ton of $CO_2$ emission. They included also the indirect emissions from intermediate goods. Difference between the productivity of the lowest and highest ten percent was 2.27 log points, which translates into 870 percent difference in emission productivity using 375 within-industry 90-10 dispersion measures. The productivity difference means that energy efficiency could be easily improved, if firms were incentivized to do so.

Even though the EU ETS has been running for fifteen years, we have mostly data and research from the first two phases between 2005-2007 and 2008-2012. In the early phases most of the allowances were allocated for free, but a larger share of them has been auctioned after 2013. In the third phase annual caps have decreased by fixed 1.74 % and the price of an allowance has risen since 2017 from below EUR 5 to quite steady above EUR 20 (Sandberg -website, EUA price).

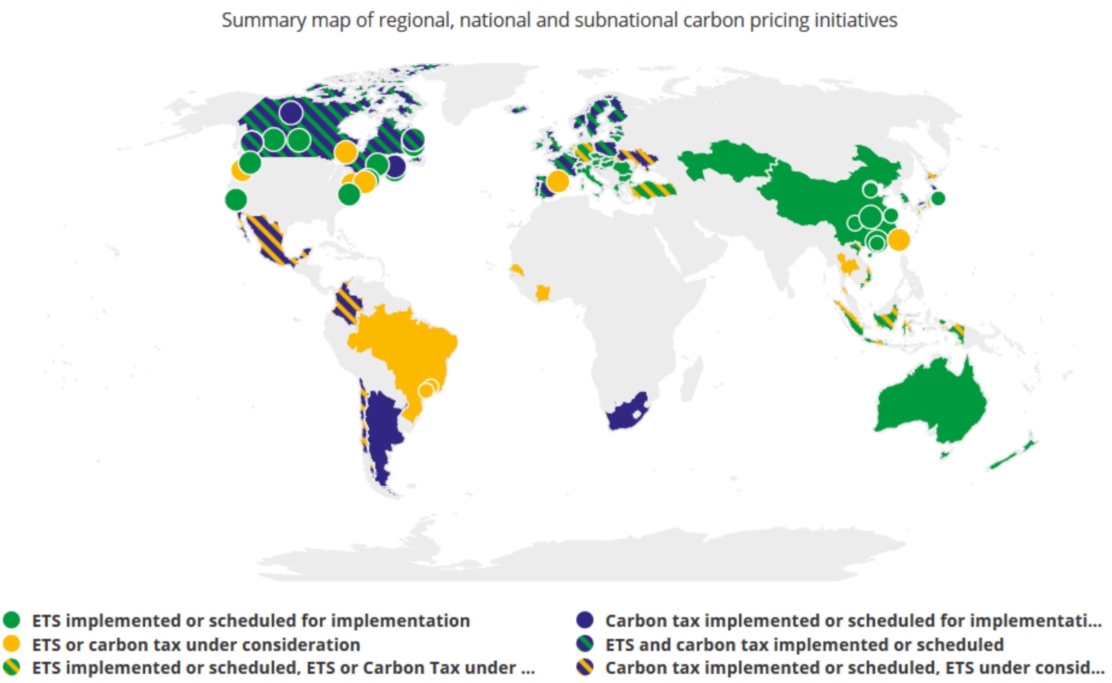


*Figure 1: Current and upcoming carbon pricing schemes in the world. Source: Carbon Pricing Dashboard, World Bank. Referred in March, 2020.*

It is important to study the total effects of EU's main environmental policy, as other similar carbon pricing policies are being implemented and evolving. New carbon tax -regimes and emission trading systems have been implemented or scheduled, for example in California and China as seen in Figure 1.

## 2.1 Institutional elements of EU ETS

The EU ETS covers 12 000 power stations and manufacturing plants in the 28 EU Member States and in Iceland, Liechtenstein and Norway, as well as 1400 aircraft operators operating intra ETS area (European Environment Agency, 2018). In Finland 460 plants surrendered allowances in 2017 according to Finnish Energy Authority. 45 % of total EU greenhouse gas emissions are regulated by the policy within EU. The EU ETS remains the world's largest emissions trading market, accounting for over three-quarters of international carbon trading. (European Commission, Factsheet of EU ETS, 2016)

EU's Emission Trading Scheme or System (EU ETS) is EU's main environmental policy to reduce greenhouse gas -emissions (GHG) in the atmosphere affecting global warming and climate change. The objective of European Council is to limit global average temperature increase to 2 °C above pre-industrial level (European Council, 7224/1/07). Regulated industries are energy-intensive industries within the manufacturing and the power sector, i.e. combustion installations with a rated thermal input capacity of at least 20 MW, refineries, coke ovens, steel plants, and installations producing cement clinker, lime, bricks, glass, pulp and paper. Since 2012, the aviation sector has also been added to the EU ETS. (Eugénie, Sommerfeld, 2019).

EU ETS works by setting a cap on the maximum level of emissions for the sectors covered for each period called phases. The cap guarantees that emissions won't reach the pre-defined level in the period the cap applies. Covered installations are obliged to submit an EU emission allowance (EUA) for each tonne of carbon dioxide equivalent ($CO_2$ eq.) emitted within a year. (Chandreyee and Velten, 2014). If installation fails to surrender enough allowances in time, the penalty is 100 euros per $tCO_2$ in addition to submitting the required allowances (European Commission, EU ETS handbook, 2015).

In each period allowances are allocated for free or they are auctioned for participating installations. Emitters whose abatement costs are lower than the EUA price find it profitable to reduce emissions. Emitters with high reduction costs can buy EUAs and postpone their own action thereby complying with the GHG policy more cheaply than they otherwise would have been able to. (Chandreyee and Velten, 2014.)

Allowances are accurately tracked in Union registry, where each participant of EU ETS must open an account. Anyone can possess an account and is able to buy and sell allowances regardless if they are participating to the policy or not. Trading is possible without brokers and can be used for speculative purposes as well. (Chandreyee and Velten, 2014).

### 2.2 Development of EU ETS

Intergovernmental Panel on Climate Change (IPCC), a scientific intergovernmental body under the auspice of the United Nations, launched its first summary of climate change in 1990. In 1993 EU Council established decision (93/389/EEC), which mandated Member States to monitor and report their annual GHG emissions. Regulatory measures concerning energy efficiency were implemented, such as labelling standards for household appliances. (Prahl, Hofmann 2014).

In climate summit in Kyoto in 1997 industrialized countries agreed to reduce their emissions during commitment period 2008-2012 by 8 % compared to 1990 levels. In the start of new millennium, EU started actively improving its climate policies by launching the European Climate Change Programme (ECCP), which examined possibilities for GHG emissions reduction and how to meet Kyoto targets. From this programme European Emission Trading Scheme (ETS) was introduced. EU ETS was launched as a directive (2003/87/EC) in October 2003. (Prahl, Hofmann 2014). The directive determines regulated industries and their installation maximum capacity thresholds, which determine does installation fall within the policy or not. The thresholds are the following (2003/87/EC):

- Energy activities: Combustion installations with a rated thermal input exceeding 20 MW
- Production and processing of ferrous metals: installations for the production of pig iron or steel (primary or secondary fusion) including continuous casting, with a capacity exceeding 2,5 tonnes per hour
- Mineral industry: Installations for the production of cement clinker in rotary kilns with a production capacity exceeding 500 tonnes per day or lime in rotary kilns with a production capacity exceeding 50 tonnes per day or in other furnaces with a production capacity exceeding 50 tonnes per day
- Mineral industry: Installations for the manufacture of glass including glass fibre with a melting capacity exceeding 20 tonnes per day

- Mineral industry: Installations for the manufacture of ceramic products by firing, in particular roofing tiles, bricks, refractory bricks, tiles, stoneware or porcelain, with a production capacity exceeding 75 tonnes per day, and/or with a kiln capacity exceeding 4 $m^3$ and with a setting density per kiln exceeding 300 $kg/m^3$
- Other activities: paper and board with a production capacity exceeding 20 tonnes per day

This means that the participation to the policy is determined by quite fixed characteristics of the installations. In theory, the plants could avoid the policy by downsizing their production capacity, but presumably with high cost in lost production and equipment change.

EU ETS started the 1st of January 2005. The directive 2003/87/EC instructed to allocate almost all allowances for free in the beginning of the policy. In Phase I (2005-2007) at least 95 % of allowances had to be allocated for free. In Phase II (2008-2012) free allowance minimum requirement drop to 90 %.

The initial amount for allowances was determined for each Member state by their own request in form of national allocation plans, which the European Commission assessed. Member states decided for themselves the total number of allowances as well as how they were allocated to installations. As an aggregate from these national allocations became the EU-wide cap. European Commission required adjustments in plans if they were inconsistent with the progress towards Kyoto targets. (European Commission, national allocation plans).

In 2007 the Head of Member states introduced their 20-20-20 by 2020 -target (224/1/07). EU made commitment to achieve at least 20 % reduction by 2020. The Council targeted to increase energy efficiency in the EU to save 20 % of the EU's energy consumption compared to projections for 2020. Also 20 % of overall energy use should be from renewable energy sources in EU by 2020.

In 2009 amendment Council decided to have a single EU-wide cap instead of national caps for each member state for the phase III (2013-2020). Also, the cap started to decrease by 1.74 % linearly annually. The share of free allocation of allowances was decreased, and in 2013 40 % of allowances were auctioned. (European Commission, EU ETS, auctioning).

During phase III (2013-2020) there was a surplus of allowances on the market, as the emissions had decreased below projections due to Financial crisis. As the surplus of allowances reduced the allowance price, the surplus disincentivized the technological changes to meet the targets in the future. In 2015 the number of surplus allowances was 2 billion. Auctioning of 900 million allowances was postponed from 2013-2015 and later added to the market stability reserve. A market stability reserve was created as a legislation in 2015 and started to operate in January 2019. (European Commission, market stability reserve). The rule is that amount of 12 % of allowances in circulation are deducted from the annually auctioned cap and placed in the reserve. They are released from the reserve to Member states by same proportion as was originally withdrawn when number of allowances in circulation is less than 400 million. (Decision (EU) 2015/1814).

During the phase IV (2021-2030) overall number of allowances will decline at annual rate of 2.2 % instead of 1.74 % as in Phase III. The reduction target for 2030 is 43 % compared to 2005 level. Free allocation will be focused only on the sectors at the highest risk of relocating outside EU. For other sectors free allocation will decline from 2026 from 30 % to 0 % by 2030. (European Commission, Revision for phase 4).

### 2.3 Progress of emission reduction compared to targets

Emission reduction is real when regulated companies reduce the emissions per unit of output without losing market shares for firms with higher emissions (Muûls, Colmer, Martin and Wagner, 2016.)

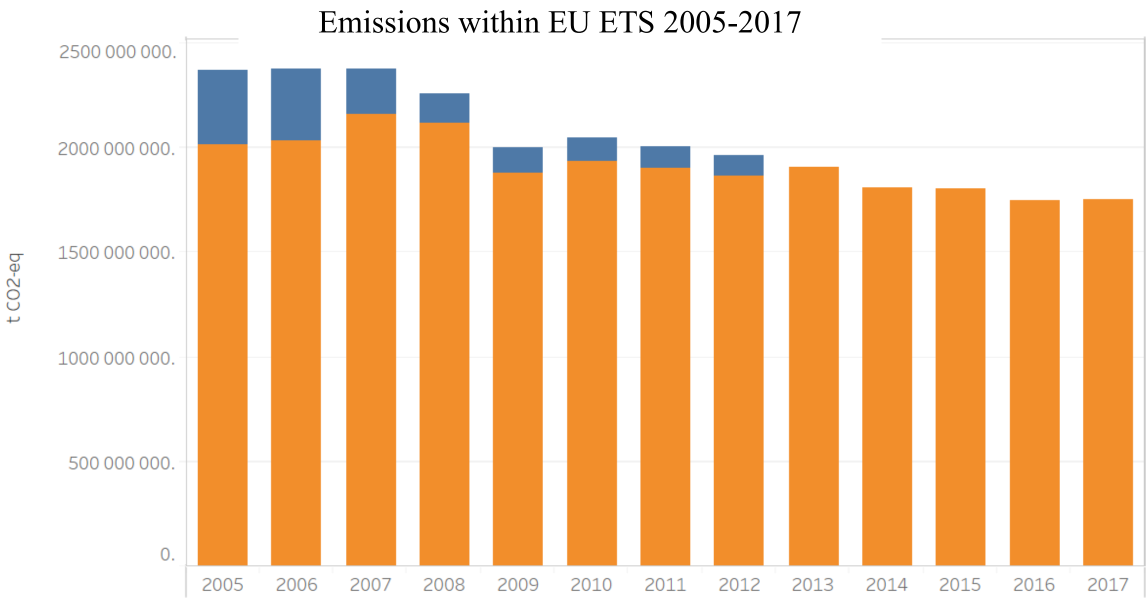


*Figure 2: Historical emissions of all installations in EU ETS countries. Blue bars reflect current ETS scope for allowances and emissions. Source: European Environmental Agency*

Since 2005 emission in manufacturing installation in EU ETS area have decreased by 26 % to year 2017 according to the European Environmental Agency's verified emissions as seen in Figure 2. According to Muûls, Colmer, Martin and Wagner (2016) emission in Europe have been dropping before EU ETS. All reduction in Europe cannot be counted as the effect of the policy. The financial crisis and following recession dropped the emissions in Europe. Difficulties on evaluating the effect of EU ETS on emissions include that there is no data on emissions before 2005. It is also difficult to define a control group, as being part of EU ETS is not a randomly assigned treatment.

According to European Commission (2018) EU remains on track to reach its 2020 target of reducing GHG emissions by 20 % from 1990 levels. In 2017, EU GHG emissions were down by 22 %, according to preliminary data. As Member States' projections indicate that emissions will decrease further, the EU expects to meet its 2020 target.

In 2005 the total verified emissions in Finland were 33.1 million tonnes. In 2017 emissions had dropped by 24 % to 25 million tonnes. (Finnish Energy Authority.)

The GHG emission intensity of the economy, defined as the ratio between emissions and GDP, fell to a record low of 315 g CO2eq. / EUR, which is half the 1990 level. Between 1990 and 2017, the EU's combined GDP grew by 58 %, while total GHG emissions decreased by 22 %. (European Commission, 2018.)

Traditional inventories, such as EU ETS verified emissions, do not include emissions associated with imported goods. GHG emissions of production within EU area are part of the policy, but emissions associated with the consumption are not. For example, net emissions from export and imports for Finland in 2014 were 22 $MtCO_2$ where as China, Russia and India were massive emission net exporters (Carbon Brief, 2017). Therefore, as the EU ETS policy focuses on emissions from production within its borders, it excludes imported emissions associated with the production of imported goods.

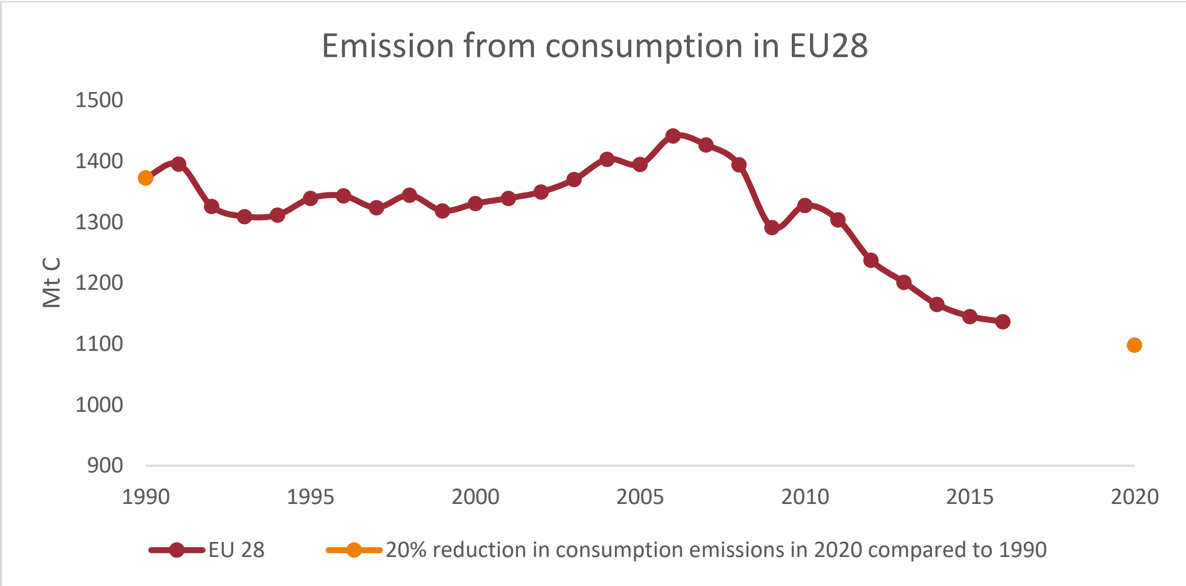


*Figure 3: Emissions from consumption in EU28 in million tonnes of carbon. Added a point for 20 % reduction target compared to 1990 to illustrate the emission development in consumption. Data source: Global carbon budget 2018 (Peters, GP, Minx, JC, Weber, CL and Edenhofer, O)*

In Figure 3 are illustrated the emissions associated with consumption within EU28 area. It seems that emissions are not largely outsourced to other countries. The target to reduce emissions by 20 % to 1990 level seems to be fulfilling even if imported emissions are included according to the data from Global carbon budget 2018.

Wagner, Muûls, Martin & Colmer (2014) found at installation-level using survey data from French manufacturing that emissions reduction has increased up to 20 % relative to non-ETS plants in the first two phases. They observed that the main driver of the reduction seems to be lower carbon intensity in the fuels used by the plants. They didn’t find significant evidence, that firms would have allocated production from ETS-plants to non-ETS plants. They couldn’t take carbon leakage between markets into account to analyse whether this could be an important source of the reduction and therefore the estimated 20 % reduction is an upper bound.

But is the emission reduction real or are the carbon emissions leaking to unregulated countries as feared beforehand? Dechezleprêtre and Sato (2017) summarize, that the recent evidence appears to offer broad support for the existence of a pollution haven effect, with imports of pollution- or energy-intensive goods increasing in response to tighter regulation. However, the effects tend to be small and concentrated in a few sectors.

### 2.4 Emissions from regulated installations in Finland

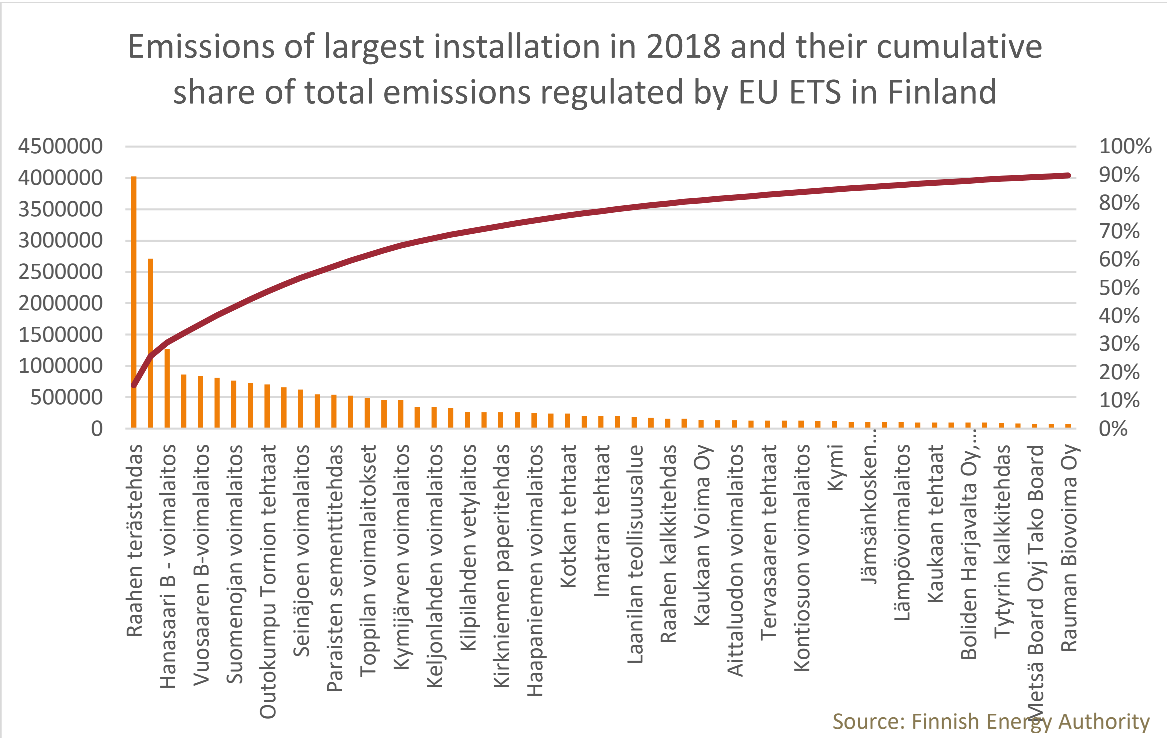


*Figure 4. Emission of largest installations in Finland in 2018 and their cumulative share of total emissions in Finland. Source: Finnish Energy Authority.*

In 2018 there were 454 installation in Finland participating to EU ETS and had positive verified emissions according to the installation-level information from Finnish Energy Authority. A few largest installations emit a high share of all regulated emissions in Finland. 30 % of emissions came from the 3 largest installations: SSAB Europe Oy's steel factory in Raahe, Neste Oy's refinery in Porvoo and Helen Oy's Hanasaari B -power plant. 50 % of the emissions originated from the 10 largest installations.

### 2.5 Finland’s share of revenue EU allowances auctions

The total cost of the policy for Finnish companies can be analysed from the allowance auction data. The auctions of the allowances are held in the European Energy Exchange (EEX) since 2016. (European Commission, EU ETS, auctioning of allowances).

| Year | Number of Allowances M | Revenue M EUR | Average price |
|---|---|---|---|
| 2012 | 2 | 13.3 | 6.76 |
| 2013 | 15.2 | 67 | 4.4 |
| 2014 | 10.8 | 63.5 | 5.91 |
| 2015 | 12.3 | 93.7 | 7.64 |
| 2016 | 13.5 | 71.2 | 5.25 |
| 2017 | 16.5 | 95.3 | 5.75 |
| 2018 | 16.3 | 251.8 | 15.68 |

*Table 1. Finland's share of the allowance auction revenues. Source: Finnish Energy Authority*

Finland gain from allowance auctions EUR 252 million in 2018, as the average price almost tripled from previous year. In previous years the revenue has been smaller, in 2012 the revenue was only EUR 13 million. The decreased share of free allocation in phase III can be captured as significant increase in number of auctioned allowances from 2 million to 15 million in 2013 as seen in Table 1.

## 3 THE POSSIBLE RELATION OF THE POLICY TO EARNINGS

The increased production costs can be passed through to end prices, if the demand is price inelastic. This means that the quantity demanded isn’t sensitive to changes in price. But if the demand is price elastic, meaning the increased price decreases the demanded quantity relatively more, the increased carbon costs must be borne within the supplier. This means either diminishing production and therefore also labour needed for the remaining activity or finding the most flexible ways within the production function to bear the costs.

The cost pass-through of the policy costs is considered similarly as tax incidence, when it is investigated who bears the cost of taxation regardless of the point the tax revenue is collected. The cost of the policy can be considered as a tax. The question who bears the cost depends on the extent to which the firm can pass-through these costs to others whether it is the end consumers, but also to the industry to the suppliers of labour, capital, energy and materials. (European Commission, 2015.)

To visually illustrate the case of cost pass-through to end-consumers, we can look at the case of production cost increase in the supply-demand diagram. The supply curve shifts left as production costs increase by the carbon pricing, *ceteris paribus*.

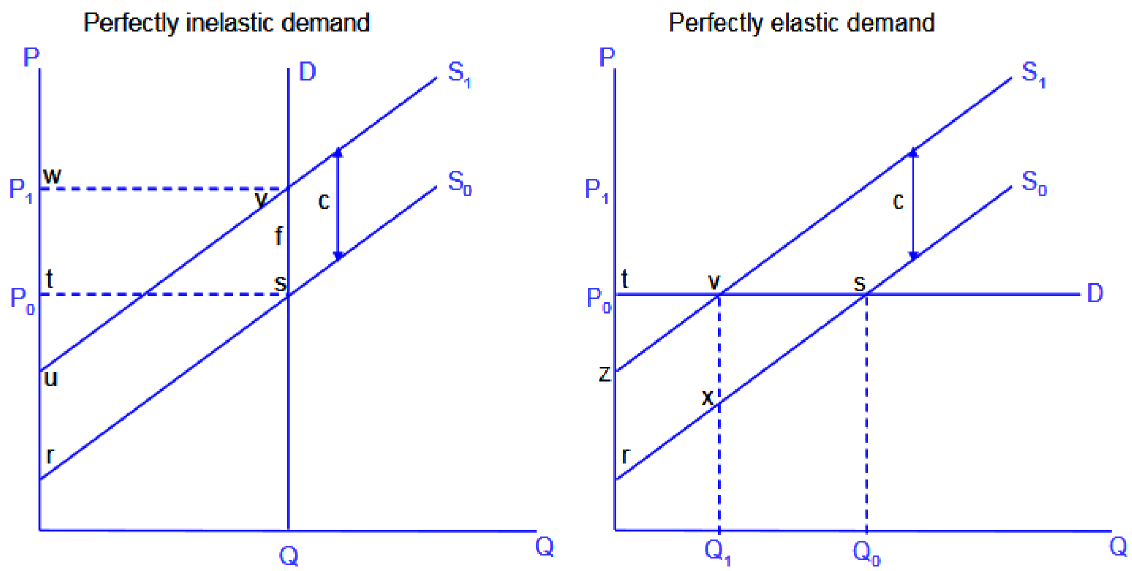


*Figure 5. Pass-through of increased production costs when demand is perfectly price inelastic and perfectly price elastic. Source: Sijm & Chen (2009).*

On the left-hand-side of Figure 5 the demand is perfectly price inelastic, meaning the quantity demanded is unaffected by changes in price. As the supply curve shifts left due to increased marginal costs, the producer can pass on the increased marginal costs fully to the consumers and keep its own surplus unchanged. (Sijm & Chen, 2009.) When demand is perfectly price inelastic, the supply side can stay unchanged and there would be no pressure for the supply of labour.

On the right-hand-side of Figure 5, the demand is perfectly price elastic, meaning that the price is fixed due to competition. The producer internalizes the emission cost to its output decisions and adjusts the production until price equals marginal costs. The quantity decreases from $Q_0$ to $Q_1$ and the surplus of the producer diminishes. (Sijm & Chen, 2009.) This negative shock would decrease the demand for labour, meaning decreased employment and decreased the equilibrium wage. This could be the case if the suppliers produce undifferentiated products in competitive market.

To illustrate the cost pass-through between demand and supply more closely, the simple illustration of Weyl and Fabinger (2013) quantifies the tax incidence. Tax incidence is a ratio of tax borne by consumers compared to that borne by producers and cost of the policy behaves similarly as a tax. The incidence *I* equals the ratio of pass-through rates

$$I = \frac{\rho}{(1 - \rho)} \tag{1}$$

Where the pass-through rate $\rho$ depends on the elasticities of demand and supply

$$\rho = \frac{1}{1+\left(\frac{\epsilon_D}{\epsilon_S}\right)} \tag{2}$$

where $\epsilon_D$ is the elasticity of demand and $\epsilon_S$ is the elasticity of supply

$$\epsilon_D = -(D'p/Q) \tag{3}$$

$$\epsilon_S = S'p/Q \tag{4}$$

And elasticities mean the relative change in quantities when price changes a little.

The key point of the equations is to notice that the cost is borne by the inelastic side of the market.

According to European Commission's report (2015) the pass-through rates to end consumer depend on market power, elasticities of demand, the elasticity of domestic supply and elasticities of foreign supply. These factors are difficult to study empirically, so measurable drivers are used for estimation. Such drivers are trade intensity, transport costs, tariff barriers and product substitutability, as well as indicators of market concentration and pricing power. (European Commission, 2015.)

According to the ex-post analysis of the pass-through of carbon costs made by European Commission (2015), in addition to elasticity of demand in the EU market, the rate of pass-through depends also on the marginal cost of supply of EU manufacturers. The more elastic the supply curve, the more costs are passed through. Another factor is the marginal cost price difference between EU and non-EU manufacturers. If non-EU exporter has perfectly elastic marginal cost curve, they can increase export at lower marginal cost than EU producers if transport costs are low enough. To compete, EU producers couldn't pass on the costs. If non-EU producers already function at full capacity, the marginal cost is increasing when they increase output therefore diminishing their impact on EU producers pass-though. They found that market power both within EU and in international markets, including bargaining power, and exposure to international competition seem to be among the main driving forces of both price formation processes and the ability to pass through carbon costs.

The emission scheme can cause investment in energy efficient production technologies, to pay less for the emission costs. This would change the production function and could make the reduction in production unnecessary. This is called input substitution, which is the wished outcome of the policy. (Ganapati, Shapiro & Walker, 2016).

## 3.1 Hypothesis of the effect of the policy on suppliers

There are three hypotheses of the overall effect of the policy on regulated installations. First one is the pollution haven hypothesis, which assumes that increased environmental costs diminish firms' international competitiveness. (Dechezleprêtre & Sato, 2017.) Therefore, regulated companies would lose market shares and even relocate to areas with laxer policies. This would mean decrease in demand for labour and negative pressure on the equilibrium wages.

The second hypothesis is Porter hypothesis, which states that because of innovation effect and early-mover advantage, the regulated companies would gain market share by being more innovative because of the policy (Porter and van der Linde, 1995). Increased efficiency and innovative solutions could increase market shares and therefore increase employment and equilibrium wages.

Third hypothesis is zero effect. It could be, that the life span of the policy is too short and the policy too lax to affect the firms. As the policy started with a laxed cap and the market has flooded with allowance surplus, the costs of carbon emissions could have remained small compared to other operational costs of the manufacturing industry, so the policy hadn't impacted the production.

### 3.1.1 Pollution haven hypothesis

According to Dechezleprêtre and Sato (2017) higher regulatory costs could, for example, crowd out productive investment in innovation or efficiency improvements and slow down productivity growth. If increased regulatory costs are passed through to product prices in competitive product markets, distortions in trade could occur, as product prices would increase more in countries with relatively strict regulation. Companies in countries with higher costs will then lose market share to competitors in countries producing emission-intensive exports more cheaply. If environmental regulatory differences are expected to last, companies' decisions regarding the location of new production facilities or foreign direct investment may also be affected, with emission-intensive sectors, and thus manufacturing employment, possibly gravitating toward countries with relatively lax policies and creating pollution havens.

Directly in line with the pollution haven hypothesis, the policy could induce relocation of regulated companies to laxer policy areas decreasing demand for labour decreasing their equilibrium wage. Similarly, if companies downsized their capacity below the EU ETS regulatory threshold to avoid the policy, the demand for labour would decrease.

Indirectly wages could be affected due to uncertainty that surrounds the policy. For companies it has been difficult to anticipate how binding the cap will really be and what are the future prices. It has also been unclear how much free allocation the firm will get in the future and will the policy even hold. This uncertainty could make the company unwilling to increase the wages of the employees as the cost of the policy can be somewhat uncertain whereas wages are very inflexible downwards. Uncertainty around the costs could have decreased willingness to hire new employees.

### 3.1.2 Porter hypothesis

On contrary to pollution haven hypothesis, Porter hypothesis states that environmental policy can have a net-positive effect on regulated companies' competitiveness through innovation effect and early-mover advantage. Porter and van der Linde (1995) considered competitiveness to be dynamically based on innovation, instead of looking at the world in static state, where regulation inevitably raises costs and reduces market share. They argue that companies may not be aware of true cost of toxicity, waste, discharges and second-order impact waste and that orientation should be shifted from pollution control to resource productivity. As they consider environmental regulation in general, the hypothesis can be applied to EU ETS.

They assume, that stringent environmental regulation can enhance innovation and increase efficiency in various ways. Corporate awareness increases as regulation forces them to gather information. Regulation signals companies about resource inefficiency and potential technological improvements. Uncertainty around the profitability of environmental innovations decreases. Regulation creates pressure for innovation and progress. During transitions period to innovation-based solutions, other companies can't opportunistically gain position by avoiding environmental investment as policy is mandatory. Before innovation-based solutions, regulation improves environmental quality as regulation guarantees sufficient emission reduction. Stringent environmental policy can create early-mover advantage, as early innovators of less polluting technology can profit by selling internationally.

If Porter's hypothesis would hold, there would be seen higher employment and maybe increased earnings of those employed, as high-skilled labour would be more in demand. It could be that in the industry some firms may live up to first-mover advantage, but the effect doesn't cover the whole sector.

Research and development activities take time to become commercialized products. It can be that the positive competitive effects of the policy will be more apparent with a long lag.

#### 3.1.3 Zero effect

It could be that the total costs of the policy have remained low for the companies, as a high share of allowances have been allocated for free and there has been a surplus of allowances on the market reducing the allowance costs. If the policy costs compared to other operational costs have been hardly noticeable, there would have been no need to pass the costs to end-prices or to be borne within the supply side. It could be that even though firms know that the number of allowances is decreasing, they haven't made costly investments for emission-efficient solutions and the supply side have been mostly intact.

### 3.2 Share of emission expenditure and personnel costs

How expensive is the emissions trading policy for the companies under EU ETS? Firms don't explicitly report their emissions expenses in their annual income statement whereas personnel costs are specified. To better understand the expenses for the companies, I took

Finnish manufacturing company Neste as an illustrative example of how much they have paid for emission allowances (EUR 4.2 million in 2017) and what is the share of emission costs of total operating expenses (0.04 %).

### 3.2.1 Example company: Neste

Neste is publicly held Finnish company operating in Scandinavia and Russia, which focuses on oil finery, oil retail, renewable solutions and marketing and services (Neste's website). Neste had the third largest emission in Finland in 2017 according to Finnish Energy authority. According to Neste's annual report the revenue of Neste corporation was EUR 13 billion and operating expenses EUR 12 billion. They spent EUR 370 million for personnel costs for 5 300 employees. According to the Energy Authority they emitted 3 million tonnes of GHG emissions in 2017. Ministry of Economic Affairs and Employment of Finland is responsible for the free allocation of allowances in 2013-2020 (in later phases Energy Authority has taken that role) and according to their reports they allocated 2.3 million free allowances for Neste in 2017. Therefore, Neste had to pay for 736 000 allowances. Using closing prices of the EU Emission allowances in Markets insiders the average price of an allowance in 2017 was 5.76 euros. Therefore, Neste had to pay approximately EUR 4.2 million for emission allowances in 2017. According to Finnish Energy Authority Neste didn't receive subsidies for emission trading. Therefore, personnel costs were 3 % of total operating expenses in 2017, the emission allowance expenses were only 0.04 %. Even though the EUA price increased in 2018 and averaged over 15 euros, the share of emission costs wouldn't increase notably.

### 3.2.2 Example installation: Outokumpu's steel plant in Tornio

According to Finnish Energy Authority Outokumpu's stainless steel plant in Tornio was the 9th highest emitting installation in Finland in 2017 and they emitted 640 302 t $CO_2$. Tornio operation is the only fully integrated stainless steel -facility in the world meaning a production line from mining to an end-product (Outokumpu's Tornio website). According to free allocation decision made by the Ministry of Economic Affairs and Employment of Finland, in 2017 they received 612 709 free allowances. Therefore, they had to buy 27 593 allowances. Using the average price of 5.76 of the allowances for year 2017 as for the Neste example, the total cost of emission allowances was approximately EUR 158 900. As

Outokumpu is a large corporation with multiple production sites in global locations, they don't enclose the costs of the personnel or production costs of individual factories. In Outokumpu's annual report for 2017 they stated that because of free allocation which is based on efficiency-based benchmarks and historical activity, the total free allocation was sufficient for European operations, although individual plants were in deficit. Therefore, the entire corporation didn't pay for the allowances in 2017. If only considering the cost of the of the steel factory in Tornio the presumed EUR 158 900 for the allowances seems small compared to the annual capacity of 1.2 million tonnes of stainless steel per year (Outokumpu's Tornio webpage).

### 3.3 Additional costs of the policy

In addition to paying allowance price for producers' own emissions, EU ETS policy increases costs of the input. For example, electricity producers must comply with the policy and they may have passed on the cost to their end-prices. The policy adds these indirect costs to intermediate use, transportation and administration.

Dechezleprêtre and Sato (2017) estimated that the EU ETS increased average material costs (including fuel) for regulated firms by 5 percent to 8 percent. Differences in environmental regulations between areas can thus alter the competition between firms by changing their relative production costs. For studies that form the control group within the regulated area, it is good to keep in mind that through the indirect cost also the unregulated plants are affected by the policy. (Martin, Muûls & Wagner, 2016.)

Participation to EU ETS causes administrative costs for the companies. Heindl (2017) studied EU ETS related transaction costs in Germany. These costs include monitoring, reporting and verification (MRV), trading, general information gathering and legal costs. Managers were asked an estimation of labour days that have been spend on EU ETS related activities. The results of average transaction costs for companies that have more than 249 employees differed from EUR 0.47 per $tCO_2$ to EUR 0.02 as the emissions grew from 25 000 to 1 000 000 $tCO_2$. The administrative costs were higher for non-utility companies than for utility companies (a supplier of for example gas).

The idea of the policy is to direct the producers to more eco-friendly practises. As the policy had made the firms aware of their emissions, firms may have invested in less-polluting solution to increase their resource-efficiency. These investments would go well beyond what firms are currently paying for the allowances.

### 3.4 Possible cross-dependencies of earnings

Participation to the policy is determined for each installation by their sector and maximum capacity. On the contrary, earnings of employees between installations are not independent. Earnings are strongly related within a same company, but also within a sector and even between sectors. Employees in same sector also belong to the same trade unions, which have negotiated minimum requirements for the union members and therefore the employer can have little impact on the nominal wages apart from hiring and firing. Workers in above and below belong to same trade unions and are influenced by same collective bargaining labour agreements. This makes the wages to some extent rigid, especially downwards, as the wages are not flexibly determined by the demand and supply of labour.

This cross-dependency of employee contracts smoothens all effects the policy can have on the supply of labour. But it probably wouldn't change the direction or totally dissipate the result, if the policy affects installations significantly.

## 4 LITERATURE REVIEW

It seems that the effect of EU ETS on earnings or wages has not yet been studied at installation level. Many studies have been conducted at company-level, as the personnel costs, number of employees and other financial information is often only available at company-level. But as the participation to EU ETS is determined at installation-level, the company-level analysis is somewhat underestimating the result. Often participation is determined if at least one of firm's installations functions under EU ETS. Therefore, these partly or fully regulated companies are compared to not regulated companies and the difference between party participating and non-participating can be minor in terms of costs of emissions, as the non-regulated companies also face the indirect costs of the policy.

The number of peer-reviewed ex-post empirical analysis of EU ETS is somewhat limited, as data becomes available with a delay and proper identification strategies are difficult with an EU-wide policy. Here we go through relevant empirical findings concerning wages, employment, competitiveness and innovation.

## 4.1 Analysis of the effect of EU ETS on wages and employment at company-level

The closest study relating to our question of EU ETS and earnings was conducted at company-level in 2018 using data from 19 EU countries. Marin, Marino and Pellegrin (2018) studied the effect of EU ETS on many measures, where treatment group included firms that have at least one installation under EU ETS, whereas the control group was composed of similar firms with plants that are not part of the policy. They use data from European Union Transaction Log (EUTL), which is the register of obligated installations. They link each installation to its corresponding parent company using information from Amadeus. They used only firms which are present in each time window of the analysis (pre-treatment, Phase I and Phase II). With exact matching on sector- and country-level, the analysis could exclude macroeconomic unobserved shocks in a flexible way. They looked at manufacturing firms, as they are exposed to international competition, which may limit the possibility to pass-through the emission costs. This means that the burden of dealing with the EU ETS may be particularly relevant for manufacturing firms, thus raising the concern of loss of international competitiveness of EU firms and, consequently, job losses in the EU manufacturing sector. The matched companies represented 74 % of the ETS manufacturing installations in these countries and account for 88 % of verified emissions from ETS manufacturing installations over the period 2005–2012.

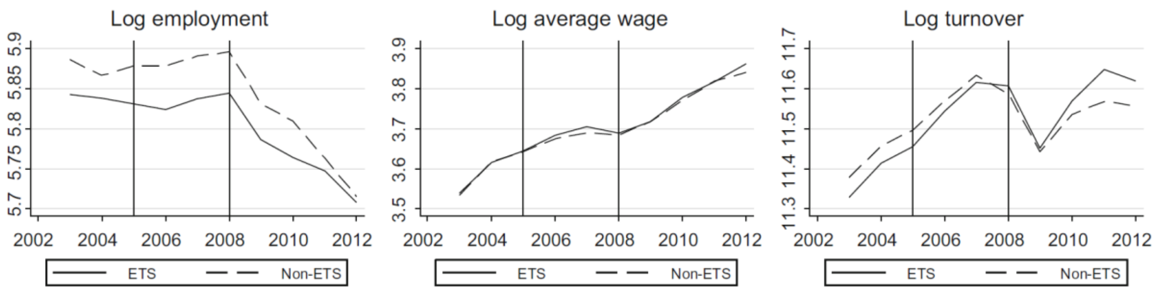


*Figure 6. Development of employment, average wage and turnover of matched companies as graphed in paper by Marin, Marino and Pellegrin (2018).*

They found during phase I employment decreased by 2 % in regulated companies, but the difference wasn't significant in phase II. The average wage didn't differ significantly in either phases. The turnover was 7 % higher in the second phase in EU ETS group. We can also notice from Figure 6 that average wage was inflexible downwards, even though employment and turnover decreased in the aftermath of financial crisis.

## 4.2 Employment at installation-level in France

Wagner, Muûls, Martin and Colmer (2014) found at installation-level using survey data from French manufacturing that employment in ETS-plants reduced by 2 % after announcement of the EU ETS in 2000 and by 7 % in phase II. They used difference-in-difference approach identifying closest match for each ETS-plant among non-ETS plants. This result show that at installation-level the effect on employment was a bit higher than at company-level.

## 4.3 Installation-level analysis of innovation in UK

Britain already had its own carbon pricing schemes such as UK ETS and Climate Change Agreement in effect when EU ETS was launched in 2005. Plants that were already carbon-regulated in Britain, could opt out entering to EU ETS up till 2007 or 2008 depending on the policy. Calel (2018) exploited this feature and made matching pairs of plants that were under UK carbon policy to EU ETS -plants. He found no significant change in adopting existing abatement technologies but found increased low-carbon patenting by 25 % and increased low-carbon R&D spending by £200,000 annually for typical innovator in 2008.

## 4.4 Company-level empirical analysis of financial performance

Calel et al. (2017) estimates the effect of EU ETS on competitiveness in exploiting installation-level inclusion criteria on firms' revenue, assets and employment up to year 2012. In this unpublished working paper, they matched installations otherwise almost similar apart from whether they are part of the policy or not. Their main finding is that ETS firms had a higher increase in revenue and assets and a lower increase in employment compared to non-ETS control firms, but the difference was always smaller than 1 standard error. Therefore, they find no significant effect of the EU ETS on firms' revenue, employment and assets in the first two phases of the policy. This can be explained by the fact nearly all allowances were allocated for free in the first phase and 97 % in the second phase.

## 4.5 Electricity pass-through rates in Spain

Fabra and Reguant (2014) studied the pass-through of emissions costs to wholesale electricity market prices in the Spanish electricity market from January 2004 to February 2006, which overlaps with the launch of EU ETS. They used reduced form and emissions price as instrumental variable for marginal emission cost to approximate the pass-through rate of emissions costs using multivariate regression and controlling for hour- and day-specific supply and demand. They found that more than 80 % of emissions costs were passed to electricity prices, meaning that EUR 1 increase in emissions costs increased prices by EUR 0.86.

European Commission (2015) conducted a large-scale analysis of EU ETS cost pass-through on the six most polluting sectors in six EU countries. They used a cost-price approach explaining the change in price in changes of the input costs trying to find out the coefficient for the carbon costs. In refinery sector cost pass-through rates ranged between 80-100% for petrol and 100% for diesel and gasoline. They pass-through rate for steel ranged between 55 % - 100 % depending on the product and region.

### 4.6 Summary of the related empirical results

| Effect of EU ETS on | Magnitude of the effect |
|---|---|
| Emission reduction | In 2017 down by 22 %<br>(20 % target by 2020) |
| Transaction cost | 0.02 - 0.47 EUR / allowance<br>Depending on economics of scale |
| Indirect cost | 5 - 8 % increase in material costs |
| Pass-through of costs<br>in electricity market | 1 EUR increase in allowance price increased end prices by 0.86 EUR |
| Innovation | +25 % low-carbon patenting |
| | +£200,000/year for low-carbon R&D |
| Competitiveness | No effect on revenue, assets nor employment<br>Calel et al. (2017) |
| Employment | -2 % in Phase I, no effect in phase II<br>(Marin et al. 2018) |
| | -2% in 2000 when announced and -7 % in phase II<br>(Wagner et al. 2014) |
| Wages | No effect<br>(Marin et al. 2018) |

*Table 2. Summary of related empirical results*

In Table 2 the empirical results from the literature review and previous chapters are combined. Overall it seems that the policy has been able to reach its emissions reduction targets with very little negative impact on the competitiveness of the regulated entities.

# 5 EMPIRICAL ANALYSIS

We evaluate the effect of the EU ETS on earnings of employees in regulated installations. We follow the development of earnings of individuals, who worked in regulated manufacturing installations just before the policy started at the end of 2004. We follow their earnings from year 2000 to see the trend before treatment and the trend after the policy until 2016. The earnings development is compared to the earnings of a control group, which is formed of individuals working in same sectors, but in installations that are not regulated by the policy. The difference between installation being part of the policy or not is determined by the maximum capacity threshold determined by the EU ETS directive.

As the policy covers only installations that have a maximum capacity above a threshold level, the treatment group and the control group differ systematically as large installations are compared to small ones. Also, as there are larger installations in other sectors more than in others, the sectors are represented disproportionally in treatment and control groups. This is one reason why our setting doesn't allow an interpretation of a causal relationship, but we can investigate the direction of association between the policy and earnings.

## 5.1 Data sources

We use two data sources. Firstly, we recognise the installations under the policy from the data of energy use in manufacturing sector between 2007-2016 gathered by Statistics Finland. The data would be available since 1990 collected by Ministry of Trade and Industry, but the data collection for statistics was revised starting from year 2007 and that's why our first observation year starts in 2007. (Energy use in manufacturing data -webpage). The data covers only manufacturing installations, leaving out also regulated and heavy-emitting electricity sector and aviation. Concentrating on manufacturing sector seems relevant as electricity sector have, according to Fabra and Reguant (2014), a high pass-through of the costs to the end prices, most likely leaving the earnings and employment unaffected. The data covers years 2007-2016, omitting year 2005 when the policy started, which leads us to make assumption that the existence of installations in 2007 reflect sufficiently well the situation in 2005. The data includes installation codes, sector code and whether installations was part of EU ETS each year. The data at installation level has been requested from Statistics Finland for research purposes. Information of installations maximum capacities was not part of the data set.

Secondly, using installations codes, the group of employees working for these manufacturing installations are formed from Finnish Longitudinal Employer-Employee Data (FLEED) from Statistics Finland. The data includes information of annual earnings of total Finnish working population between 1989-2016, as well as background information of workers as their age, sex, when they have started to work in the installation and number of personnel on the installation. Data is based on end of year information.

### 5.2 Identifying treatment and control installations

As the policy participation information of the installation is limited to start in year 2007, we used year 2007 information. If an installation was part of the policy in 2007, it is determined as a treated installation. The control installations are formed of non-regulated installation in 2007, which belonged to same sector that had at least one regulated installation. In this analysis installations are considered to function in a same sector, if they have a same sector classification code at 5-digit-level.

The treatment and control group of employees are constructed using the workplace information from end of year 2004: those who worked in treated or controlled installations at the end of year 2004 are studied. We assume that end of year 2004 reflect well the situation in the start of year 2005. Those employees' earnings are followed between 2000-2016 regardless what happens to their employment: whether they shift establishments, sectors or exit the workforce. Therefore, we investigate the earnings development of individuals, who worked in regulated sectors at the end of year 2004, but the pool of installations is constructed using 2007 information.

### 5.3 Validity of the identifying assumptions and caveats

To allow a causal interpretation the control group should represent the same population as the treatment group to establish a trend of what would have happened without the treatment. The control group should reflect the external changes in the business environment regardless of the policy: for example, changes in demand and input prices. In such case the control group would differ only in the means of treatment and we could interpret a causal relationship.

In this analysis the sectors are compared somewhat disproportionally as regulated installations are larger than unregulated. For example, the sector of manufacture in paper and paper products dominates greatly in the treatment group. Therefore, the changes in paper sector drives the changes in treatment group without the control group reflecting these changes at same proportion. Whether the change is drive by the demand side or by the policy remains undetected.

The information of the installations participation to the policy is from year 2007. This creates a survivor bias, as we investigate establishment that still functioned after two years the policy started. It could be that some installations have withdrawn from business after the policy started. This bias can be minor as the policy started with generous free allocation, but its significance remains undetected in this study.

Other assumptions for a valid control group is that treatment has no impact on the control group. This is not fully satisfied, as the establishment outside the policy face the spill-overs from the policy as the indirect costs of the policy in their input costs such as increased electricity and fuel prices.

The controlled installation can be influenced also from the demand side. As the installations in the same sector are probably encounter the same demand curve, the control group could increase their market share, if the policy increases the prices of regulated installations.

We are not able to detect possible policy avoidance behaviour by downsizing capacity below the policy threshold, as the data omits the information of the maximum capacities of the installations and doesn't start before the policy started.

Keeping these caveats in mind, the results should be interpreted with a caution. The change between treatment group and control group can't be interpreted straight-forwardly to be fully influenced by the policy.

## 5.4 Descriptive statistics

The installation is part of the treatment group if it was part of the EU ETS in 2007. The control group is formed of installations that are on the same sector at 5-digit-level than one those regulated but is small enough not to be regulated.

**Number of installations under investigation**

| **Sector** | **Non-ETS installation** | **ETS-installation** | **Total** |
|---|---|---|---|
| Manufacture of basic metals | 3 | 7 | 10 |
| Manufacture of beverages | 3 | 3 | 6 |
| Manufacture of chemicals and chemicals products | 58 | 7 | 65 |
| Manufacture of coke and refined petroleum products | 10 | 3 | 13 |
| Manufacture of food products | 42 | 6 | 48 |
| Manufacture of motor vehicles trailers and semi-trailers | X | X | X |
| Manufacture of other non-metallic mineral products | 23 | 17 | 40 |
| Manufacture of paper and paper products | 11 | 53 | 64 |
| Manufacture of textiles | X | X | X |
| Manufacture of wood and wood products | 92 | 14 | 106 |
| Mining and quarrying | 3 | X | X |
| Repair and installation of machinery and equipment | 38 | X | X |
| Total | 286 | 115 | 401 |

*Table 3. Number of installations in the treatment and control group. X means that there are less than 3 observations and the number is hidden for confidentiality. Even though the control group was formed at 5-digit-level, they are aggregated in this table at 2-digit-level for simplicity.*

In

Table 3 we can see the number of installations that are EU ETS-regulated in 2007 and the controls formed from same sectors that year. Sectors are disproportionately represented in treatment and control group. For example, in manufacture of paper and paper products there was 53 regulated and 11 non-regulated installations. In manufacture of wood products there is much more installations in the control than treatment group. Totally there are 115 regulated and 286 unregulated installation used in this set-up.

Even though there are more installations in the control group, there are more employees working in the regulated installations as they are larger. Using information from FLEED, we get the number of employees in each installation here illustrated in each sector.

**Number of employees in the treatment and control installations**

| Sector | Non- EU ETS | EU ETS | Total |
|---|---|---|---|
| Manufacture of basic metals | 404 | 6 992 | 7 396 |
| Manufacture of beverages | 126 | 409 | 535 |
| Manufacture of chemicals and chemicals products | 4 409 | 1 893 | 6 302 |
| Manufacture of coke and refined petroleum products | 574 | 1 663 | 2 237 |
| Manufacture of food products | 2 246 | 630 | 2 876 |
| Manufacture of motor vehicles, trailers and semi-trailers | 959 | 1 080 | 2 039 |
| Manufacture of other non-metallic mineral products | 1 381 | 1 445 | 2 826 |
| Manufacture of paper and paper products | 1 576 | 21 767 | 23 343 |
| Manufacture of textiles | 322 | 627 | 949 |
| Manufacture of wood and wood products | 7 374 | 2 692 | 10 066 |
| Mining and quarrying | 72 | 126 | 198 |
| Repair and installation of machinery and equipment | 2 282 | 352 | 2 634 |
| Total | 21 725 | 39 676 | 61 401 |

*Table 4. Number of employees in treatment and control installations at the end of 2004.*

Table 4 we can see that employees in manufacture of paper and paper products are highly represented in the treatment group as there is 21 700 employees compared to 1 500 in control group. Therefore, changes in the paper sector can drive the results even though they would be unrelated to the regulation. Totally there are almost 40 000 employees in the treatment group and 22 000 in the control group.

We follow the changes in the mean earnings of these 39 676 employees working in the EU ETS -installations. Their earnings development is compared to the development of the 21 725 employees from the same sectors.

**Averages of employees' characteristics in 2000**

| | Non-EU ETS | EU ETS |
|---|---|---|
| Sex (share of men) | 0.78 | 0.80 |
| Age | 37.43 | 38.86 |
| Years of employment | 12.70 | 15.95 |
| Earnings | 25 815 | 30 672 |
| Number of employments | 1.18 | 1.15 |
| Number unemployment periods | 0.16 | 0.13 |
| Number of employees in installation | 251 | 820 |
| N | 21 725 | 39 676 |

*Table 5. Means of employees' characteristics before the regulation.*

The background information before the treatment of the employees before the treatment in 2000 do not differ much in sex ratio, age, number of employments or employment periods as seen in Table 5. Employees in EU ETS-installation have an average three years more work experience and they earn more. Also, they work in significantly larger installations, as on average there are 820 workers in EU ETS installations compared to 251 in control installations.

# 6 FINDINGS

The earnings of individuals in regulated sectors were higher by EUR 5 000 compared to the control group before the treatment, and on average the difference was dissipated by EUR 2875. It seems that the decrease is driven from lower employment level. The earnings of those who were employed decreased for the treatment group in 2005, but the earnings difference returned after that.

## 6.1 Findings of EU ETS and earnings

First, we look at the descriptive illustration of the mean annual earnings of the treatment and control group. Then we introduce the OLS-regressions results of average treatment effect and then OLS-regression estimates of yearly effect.

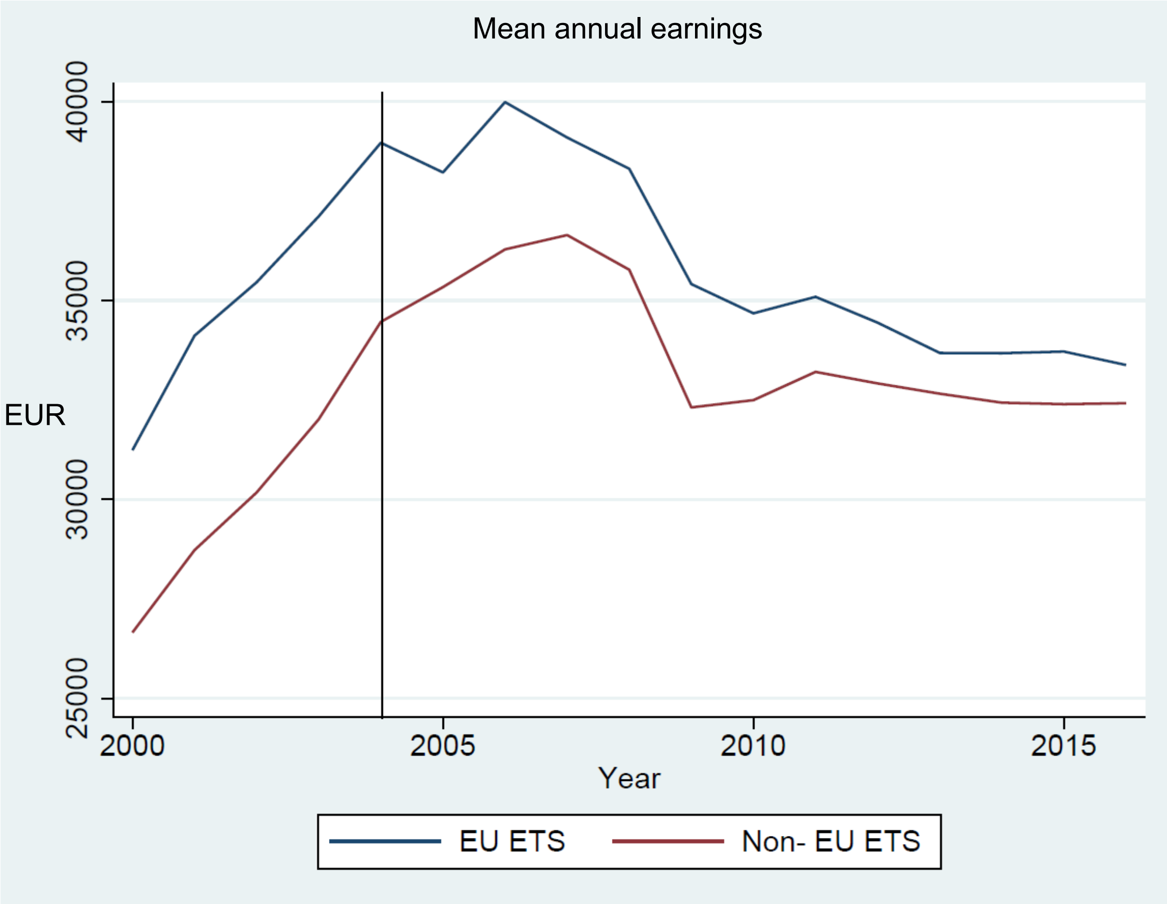


*Figure 7. Mean of annual earnings in 2000-2016 of the followed employees. The vertical line is the end of year 2004, marking the last observation year before the regulation.*

In Figure 7 we can see a parallel trend of the mean annual earnings of the EU ETS -regulated workers and their control group before the regulation started in the beginning of 2005. The parallel trend before the treatment is important for us to be able to consider the selected group as relevant control group. The workers in treatments installations earned on average EUR 5000 more than the control group before the treatment. The earnings of both groups decreased by the time of the financial crisis in 2008. The difference of average earnings between the groups seems to have almost dissipated over the years after the policy started.

The average effect of the policy to the earnings can be interpreted from the OLS regression similarly as Calel, Dechezleprêtre, Mohnen & Vehmans (2017) had done in a conference paper, which computes the average treatment effect after the policy started:

$$Earnings = \alpha + \beta_1 * ETS + \beta_2 * Post\ 2005 + \beta_3 * (ETS * Post\ 2005) + \varepsilon \qquad (5)$$

Here the variables ETS, Post 2005 and interaction term ETS * Post 2005 are dummies, getting binary values of 0 or 1. The coefficient of ETS indicates the difference between ETS and non-ETS employees. Coefficient of Post 2005 reports the mean increase between the pre-regulation period 2000-2004 and the post-regulation period 2005-2016. The potential effect of the EU ETS corresponds to the coefficient $\beta_3$ of dummy ETS * Post 2005, which can be interpreted as the treatment effect.

The following table represents the results from the OLS regression from panel data estimating the average treatment effect.

| VARIABLES | Earnings |
|---|---|
| | |
| ETS | 4,966*** |
| | (104.6) |
| Post 2005 | 3,355*** |
| | (101.4) |
| ETS * Post 2005 | -2,875*** |
| | (125.0) |
| Constant | 30,414*** |
| | (84.84) |
| | |
| *Observations* | 1,058,034 |
| *R-squared* | 0.004 |
| *Standard errors in parentheses* | |
| **** p<0.01, ** p<0.05, * p<0.1* | |

*Table 6. OLS estimates of average treatment effect of EU ETS. Here comma (,) means a thousand separator unlike otherwise in paper.*

The coefficients in Table 6 can be interpreted as, that on average the employees in EU ETS -installations earned EUR 4 966 more than their control counterparts. Post 2005 the earnings of all participants were EUR 3 355 higher than before the regulation. The coefficient for ETS * Post 2005 represents the average treatment effect and it seems that the earnings of workers in EU ETS regulated installations earned EUR 2 875 per year less what the trend of the control group would have suggested. To put this into proportion, in 2004 the average earning of EU ETS worker was 38 963, so this "lost" earnings development was 7.4 % compared to that. All the coefficients are significant in this analysis.

We have also conducted the regression analysis on yearly basis to see the effect of the policy on a yearly level. The OLS-regression formula is the following.

$$Earnings = \alpha + \beta_1 * ETS + \sum_{i=2001}^{n=16} \beta_i * Year_i + \sum_{j=2003}^{n=14} \beta_j * (Year_j * ETS) + \varepsilon \quad (6)$$

In this regression the interaction variables for three pre-treatment years are omitted to use them as base variables. The interpretation of the of the interaction variables ($Year_j$ * ETS) means the yearly change in earnings compared to the difference before the policy. As policy is decided at installation-level, the standard errors of the OLS-regression are clustering at installation-level, as earnings within a same installation are related to each other.

To make the analysis more robust, we have included the fixed effect regression models for comparison to control for the permanent time invariant change in within installation and sectors. Fixed effect analysis at firm level didn't seem reasonable as firms can have both regulated and non-regulated installations. In fixed effect model in general the group means are not considered to be dependent on each other. In the fixed affect model (command *areg* in Stata) the corresponding unit-level means are subtracted from each element of dependent variable and each element of every column of independent variables and adjusted outcomes are regressed on the adjusted covariates and indicators (McCaffrey et al. 2012).

| | | **Earnings** | |
|---|---|---|---|
| VARIABLES | (1) | (2) | (3) |
| | | | |
| 2001 | 2,603*** | 2,609*** | 2,606*** |
| | (125.6) | (151.7) | (154.5) |
| 2002 | 3,982*** | 3,990*** | 3,986*** |
| | (123.4) | (151.7) | (154.5) |
| 2003 | 5,691*** | 5,695*** | 5,691*** |
| | (214.0) | (229.0) | (233.2) |
| 2004 | 8,138*** | 8,132*** | 8,135*** |
| | (529.2) | (228.9) | (233.1) |
| 2005 | 9,012*** | 9,014*** | 9,015*** |
| | (639.7) | (229.1) | (233.3) |
| 2006 | 9,960*** | 9,973*** | 9,967*** |
| | (1,256) | (229.3) | (233.5) |
| 2007 | 10,319*** | 10,337*** | 10,328*** |
| | (1,048) | (229.5) | (233.7) |
| 2008 | 9,448*** | 9,479*** | 9,459*** |
| | (656.3) | (229.8) | (233.9) |
| 2009 | 5,988*** | 6,021*** | 6,001*** |
| | (745.6) | (230.0) | (234.2) |
| 2010 | 6,171*** | 6,197*** | 6,182*** |
| | (633.2) | (230.3) | (234.4) |
| 2011 | 6,881*** | 6,904*** | 6,887*** |
| | (680.9) | (230.8) | (234.9) |
| 2012 | 6,591*** | 6,600*** | 6,587*** |
| | (731.8) | (231.5) | (235.7) |
| 2013 | 6,333*** | 6,340*** | 6,327*** |

| | | | |
|---|---|---|---|
| | (753.9) | (232.2) | (236.4) |
| 2014 | 6,107*** | 6,113*** | 6,099*** |
| | (790.2) | (233.1) | (237.3) |
| 2015 | 6,070*** | 6,066*** | 6,055*** |
| | (816.3) | (234.3) | (238.6) |
| 2016 | 6,094*** | 6,104*** | 6,087*** |
| | (822.2) | (236.1) | (240.3) |
| 2003 * ETS | 14.18 | 17.46 | 20.42 |
| | (256.3) | (260.9) | (265.6) |
| 2004 * ETS | -584.0 | -570.7** | -575.8** |
| | (558.6) | (260.7) | (265.5) |
| 2005 * ETS | -2,204*** | -2,200*** | -2,200*** |
| | (761.5) | (261.0) | (265.7) |
| 2006 * ETS | -1,384 | -1,392*** | -1,385*** |
| | (1,370) | (261.3) | (266.0) |
| 2007 * ETS | -2,633** | -2,644*** | -2,633*** |
| | (1,159) | (261.6) | (266.3) |
| 2008 * ETS | -2,547*** | -2,573*** | -2,551*** |
| | (798.9) | (261.9) | (266.6) |
| 2009 * ETS | -1,985** | -2,014*** | -1,989*** |
| | (988.2) | (262.2) | (267.0) |
| 2010 * ETS | -2,903*** | -2,925*** | -2,906*** |
| | (1,062) | (262.5) | (267.3) |
| 2011 * ETS | -3,198*** | -3,217*** | -3,195*** |
| | (1,061) | (263.2) | (268.0) |
| 2012 * ETS | -3,558*** | -3,565*** | -3,541*** |
| | (1,115) | (264.2) | (269.0) |
| 2013 * ETS | -4,059*** | -4,064*** | -4,037*** |
| | (1,173) | (265.1) | (269.9) |
| 2014 * ETS | -3,841*** | -3,845*** | -3,812*** |
| | (1,219) | (266.4) | (271.2) |
| 2015 * ETS | -3,763*** | -3,752*** | -3,716*** |
| | (1,296) | (268.1) | (273.0) |
| 2016 * ETS | -4,124*** | -4,134*** | -4,077*** |
| | (1,239) | (270.6) | (275.5) |
| ETS | 5,084*** | - | 1,422*** |
| | (870.2) | | (145.2) |
| Constant | 26,325*** | 29,661*** | 28,724*** |
| | (684.7) | (107.3) | (145.2) |
| | | | |
| Installation fixed effect | No | Yes | No |
| Sector fixed effect | No | No | Yes |
| SE clustered at installation level | Yes | No | No |
| | | | |
| *Observations* | 1,058,034 | 1,058,034 | 1,058,034 |
| *R-squared* | 0.010 | 0.070 | 0.036 |
| *Robust standard errors in parentheses* | | | |
| **** p<0.01, ** p<0.05, * p<0.1* | | | |

*Table 7. OLS estimates of yearly treatment effect on earnings. Here comma (,) means a thousand separator unlike in rest of the paper.*

We can see in Table 7 that regardless of the chosen model the coefficients for the post-EU ETS period and being part of the policy are significant. The standard errors are smallest in installation fixed effect model *(2).* We can se that the coefficients for the post-policy period and working in EU ETS installations are negative and over the years decreasing.

In fixed model at installation level the coefficient for the treatment term ETS is omitted, as being part of the policy is time invariant variable and as such it is excluded from fixed effects model, which is determined at installation level.

The coefficients show that the treatment effect on earnings increases over the years and is more than -4000 euros for the latest observed year 2016.

In the following chapters we analyse whether the aggregate decrease in earnings is due to decrease in employment or decrease in earnings of those who have remained employed.

### 6.2 Employment

Here we look at the descriptive illustration of the employment level of the treatment and control group. Then we analyse the effect of the policy on employment using OLS-regression clustering the standard errors at installation-level.

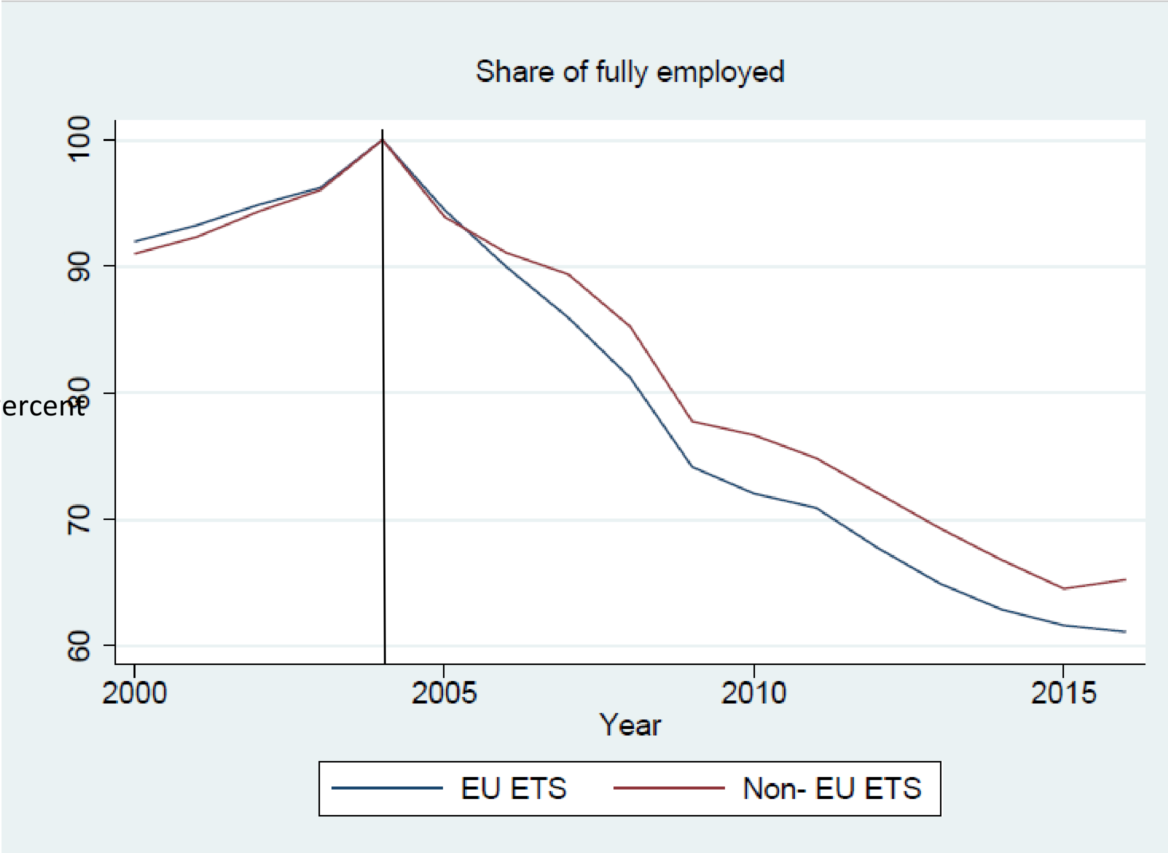


*Figure 8. Share of those fully-employment in treatment and control group.*

As illustrated in Figure 8, it seems that the employment level developed in a parallel trend before the policy. In year 2004 the employment rate for both groups were 100 as the groups were formed using the working status of that year. It seems that only a few years after the policy started the employment rate of EU ETS -workers starts to decrease more than the employment rate of the control group.

Here are the same employment rates in a table.

| | Share of fully employed | | |
|---|---|---|---|
| Year | EU ETS (%) | Non- EU ETS (%) | Difference (%-units) |
| 2000 | 92.0 | 91.0 | 1.0 |
| 2001 | 93.3 | 92.3 | 0.9 |
| 2002 | 94.9 | 94.3 | 0.5 |
| 2003 | 96.2 | 96.0 | 0.2 |
| 2004 | 100.0 | 100.0 | 0.0 |
| 2005 | 94.5 | 93.9 | 0.5 |
| 2006 | 90.0 | 91.1 | -1.1 |
| 2007 | 86.0 | 89.4 | -3.4 |
| 2008 | 81.2 | 85.2 | -4.0 |
| 2009 | 74.2 | 77.8 | -3.6 |

| | | | |
|---|---|---|---|
| 2010 | 72.0 | 76.7 | -4.6 |
| 2011 | 70.9 | 74.8 | -3.9 |
| 2012 | 67.7 | 72.1 | -4.3 |
| 2013 | 64.9 | 69.3 | -4.4 |
| 2014 | 62.9 | 66.8 | -3.9 |
| 2015 | 61.6 | 64.5 | -2.9 |
| 2016 | 61.1 | 65.2 | -4.1 |

*Table 8. Employment rate of treatment and control group 2000-2016.*

We have analysed the treatment effect on employment using the following OLS-regression:

$$Employment = \alpha + \beta_1 * ETS + \sum_{i=2001}^{n=16} \beta_i * Year_i + \sum_{j=2003}^{n=14} \beta_j * (Year_j * ETS) + \varepsilon \quad (7)$$

Here the dependent variable employment is a binary variable getting value of 1 if worker is fully employed and 0 otherwise. Therefore, the OLS-coefficients can be interpreted as how many percent units the employment rate changed in each year.

**Employment level**

| *VARIABLES* | (1) |
|---|---|
| 2001 | 0.0130*** |
| | (0.00177) |
| 2002 | 0.0305*** |
| | (0.00283) |
| 2003 | 0.0493*** |
| | (0.00350) |
| 2004 | 0.0889*** |
| | (0.00493) |
| 2005 | 0.0282*** |
| | (0.00556) |
| 2006 | -0.000205 |
| | (0.00644) |
| 2007 | -0.0173** |
| | (0.00672) |
| 2008 | -0.0587*** |
| | (0.00870) |
| 2009 | -0.134*** |
| | (0.0121) |
| 2010 | -0.144*** |
| | (0.0118) |
| 2011 | -0.163*** |
| | (0.0125) |
| 2012 | -0.190*** |
| | (0.0133) |
| 2013 | -0.218*** |
| | (0.0134) |
| 2014 | -0.243*** |
| | (0.0133) |
| 2015 | -0.266*** |

| | |
|---|---|
| | (0.0123) |
| 2016 | -0.259*** |
| | (0.0135) |
| 2003 * ETS | -0.00615 |
| | (0.00430) |
| 2004 * ETS | -0.00808 |
| | (0.00642) |
| 2005 * ETS | -0.00259 |
| | (0.00673) |
| 2006 * ETS | -0.0192** |
| | (0.00865) |
| 2007 * ETS | -0.0423*** |
| | (0.0106) |
| 2008 * ETS | -0.0485*** |
| | (0.0149) |
| 2009 * ETS | -0.0441** |
| | (0.0200) |
| 2010 * ETS | -0.0544*** |
| | (0.0196) |
| 2011 * ETS | -0.0474** |
| | (0.0196) |
| 2012 * ETS | -0.0514** |
| | (0.0208) |
| 2013 * ETS | -0.0518** |
| | (0.0203) |
| 2014 * ETS | -0.0472** |
| | (0.0200) |
| 2015 * ETS | -0.0371* |
| | (0.0193) |
| 2016 * ETS | -0.0494** |
| | (0.0198) |
| ETS | 0.00808 |
| | (0.00642) |
| Constant | 0.911*** |
| | (0.00493) |
| | |
| *SE clustered at installation level* | Yes |
| | |
| *Observations* | 1,058,034 |
| *R-squared* | 0.109 |
| *Robust standard errors in parentheses* | |
| **** p<0.01, ** p<0.05, * p<0.1* | |

*Table 9. OLS estimates of the policy effect on employment.*

The results are more statistically significant clustering the standard errors at installation level. We can see statistically significant decrease in employment rate in the treatment group, although many interaction coefficients are only statistically significant at $p < 0.05$ level. For example, in 2010 the treatment effect seems to be -0.0544 meaning 5.4 percent unit difference in employment. In 2010 the employment rate of the control group was 76.7 %. Therefore, the treatment effect translates into 7 % lower employment for the treatment group. In the last observation year in 2016, the coefficient at installation level clustering is significant at level $p < 0.05$ showing decrease in employment level by 4.9 percent units. For control group employment level of 65.2 this means 7.5 % lower employment

It seems that the policy has decreased employment of the treatment group, and it is most likely the most important factor decreasing the overall earnings. In next chapter we analyse the development of earnings of those who remained employed.

### 6.3 Earnings of employed

Here we look at a descriptive illustration of the mean annual earnings of those who were employed. Then we do an OLS-analysis on the potential treatment effect on earnings on condition that the individuals are employed.

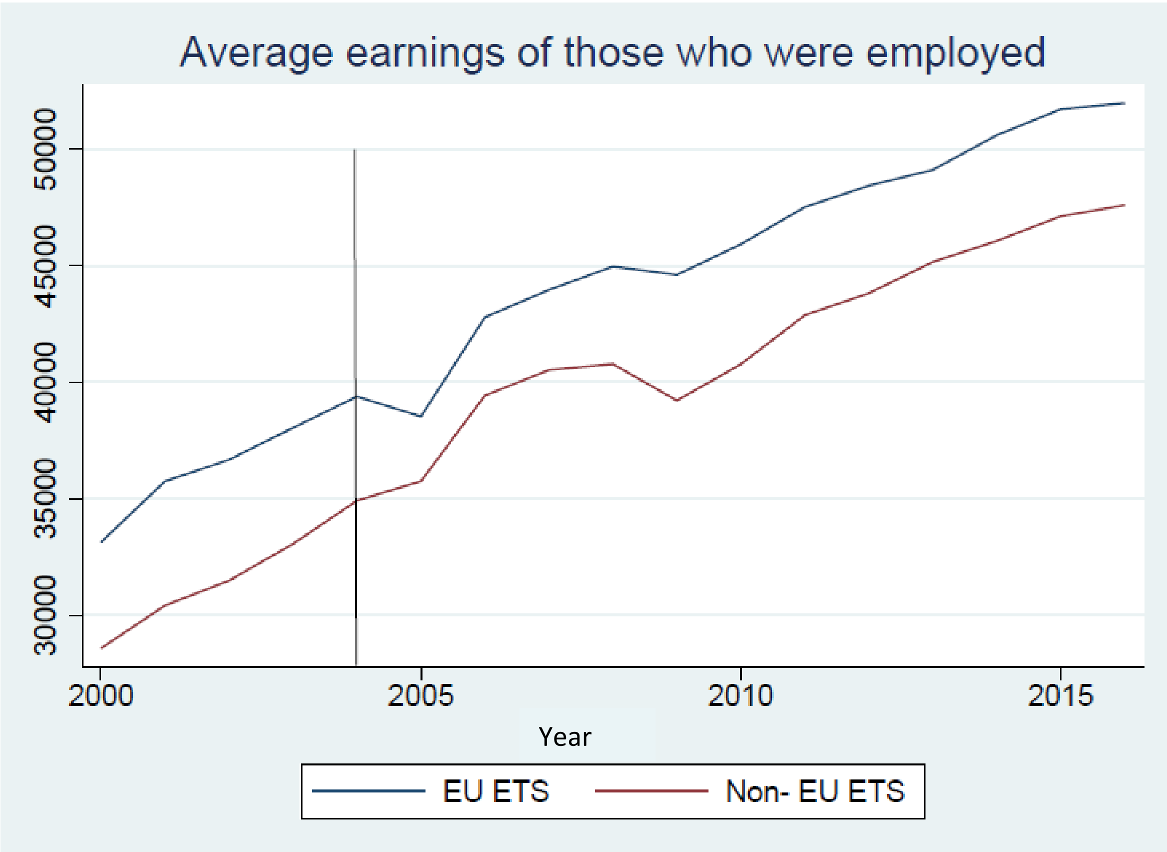


*Figure 9. Earnings of those who have been fully employed.*

In Figure 9 we see parallel trend before the treatment in earnings of employed as we saw in earnings of all in Figure 7. After the policy started the average earnings of the employed in treatment group dropped, unlike the earnings of the control group. Unlike in Figure 7 the earnings of employed have increased and the difference between treatment and control group seem to have remained after that.

Here is the same information in the mean annual earnings in a table.

**Mean annual earnings of employed**

| Year | EU ETS | Non- EU ETS | Difference |
|---|---|---|---|
| 2000 | 33 132 | 28 572 | 4 560 |
| 2001 | 35 750 | 30 413 | 5 337 |
| 2002 | 36 669 | 31 475 | 5 193 |
| 2003 | 38 039 | 33 059 | 4 980 |
| 2004 | 39 380 | 34 915 | 4 465 |
| 2005 | 38 526 | 35 749 | 2 777 |
| 2006 | 42 789 | 39 424 | 3 365 |
| 2007 | 43 966 | 40 527 | 3 438 |
| 2008 | 44 968 | 40 784 | 4 183 |
| 2009 | 44 611 | 39 209 | 5 402 |
| 2010 | 45 923 | 40 777 | 5 146 |
| 2011 | 47 523 | 42 878 | 4 645 |
| 2012 | 48 444 | 43 823 | 4 621 |
| 2013 | 49 120 | 45 164 | 3 956 |
| 2014 | 50 610 | 46 066 | 4 544 |
| 2015 | 51 725 | 47 128 | 4 597 |
| 2016 | 51 990 | 47 607 | 4 383 |

*Table 10. Mean annual earnings of employed and the difference between treatment and control group.*

Here we have run a similar OLS-regression model of earnings than for all, but now only for those who have been employed. Here the standard errors are only clustered at installation level.

**Earnings of employed**

| VARIABLES | |
|---|---|
| | |
| 2001 | 2,311*** |
| | (142.1) |
| 2002 | 3,236*** |
| | (118.9) |
| 2003 | 4,506*** |
| | (199.6) |
| 2004 | 5,931*** |
| | (495.7) |
| 2005 | 8,246*** |
| | (639.3) |
| 2006 | 10,405*** |

| | |
|---|---|
| | (1,333) |
| 2007 | 11,664*** |
| | (1,105) |
| 2008 | 11,906*** |
| | (668.5) |
| 2009 | 10,534*** |
| | (829.4) |
| 2010 | 12,098*** |
| | (691.0) |
| 2011 | 14,245*** |
| | (668.3) |
| 2012 | 15,197*** |
| | (770.7) |
| 2013 | 16,463*** |
| | (782.7) |
| 2014 | 17,325*** |
| | (902.7) |
| 2015 | 18,294*** |
| | (1,008) |
| 2016 | 18,865*** |
| | (1,075) |
| 2003 * ETS | 79.98 |
| | (213.3) |
| 2004 * ETS | -569.7 |
| | (513.0) |
| 2005 * ETS | -2,302*** |
| | (748.6) |
| 2006 * ETS | -1,029 |
| | (1,422) |
| 2007 * ETS | -1,147 |
| | (1,161) |
| 2008 * ETS | -397.0 |
| | (729.6) |
| 2009 * ETS | 750.5 |
| | (942.5) |
| 2010 * ETS | 465.9 |
| | (866.6) |
| 2011 * ETS | -6.212 |
| | (875.2) |
| 2012 * ETS | -126.9 |
| | (960.6) |
| 2013 * ETS | -648.4 |
| | (1,000.0) |
| 2014 * ETS | -90.22 |
| | (1,126) |
| 2015 * ETS | 18.33 |
| | (1,300) |
| 2016 * ETS | -303.4 |
| | (1,266) |

| | |
|---|---|
| ETS | 5,070*** |
| | (838.1) |
| Constant | 28,532*** |
| | (668.3) |
| | |
| SE clustered at installation level | Yes |
| | |
| Observations | 859,750 |
| R-squared | 0.052 |
| | |
| Robust standard errors in parentheses | |
| *** p<0.01, ** p<0.05, * p<0.1 | |

*Table 11. OLS estimates of the difference in earnings of those who are employed. Here comma (,) means a thousand separator unlike in rest of the paper.*

The interesting finding of the coefficient in Table 11 for the interaction terms only the term 2005 * ETS is statistically significant and negative as much as -2 302. Also, the ETS has significant coefficient 5 070, showing that the difference between treatment and control group remained high even after the policy as the interaction terms are not significant.

### 6.4 Result discussion

The earnings of those who worked in installations that were regulated by the policy earned more before the policy, but the difference have dissipated. This seems to be affected by their lower employment rate. Only when the policy started the earnings of those were employed nominally decreased and even more so compared to development in the control group.

It can be that the lower employment is due to reduction in production, which has been influenced by the increased carbon costs. The result doesn't tell whether companies have relocated to regions with laxer policies to avoid the costs of the policy or what is the underlying mechanism. The timing for the decrease in employment doesn't seem to be affected by the financial crisis, as employment has started be lower before year 2008.

A significant treatment effect of earnings of employed in 2005 by amount of -2 300 could be likely driven by uncertainty of the costs of the policy, as then a high share of allowances was allocated for free. The uncertainty seems to have dissipated over the years.

The follow-up of the workers doesn't straight-forwardly reflect the employment rate within the sector, as we started to follow employed individuals, who can only either keep being employed or get unemployed or exit the workforce. Therefore, our analysis doesn't straight-forwardly reflect the employment level of the studied industries. It reflects what happened to the workers whose workplaces were initially influenced by the policy.

The earnings of those who remained employed could be boosted by a positive selection bias, as most likely the least productive workers have been unemployed and therefore most likely the high earners have stayed. As the earnings in both groups seem to develop in a parallel trend, this kind of positive bias would be anyway very small.

### 6.5 Caveats and limitations

Energy use in manufacturing sector data is limited to year 2007, even though the policy started in 2005. First the regulated installations were recognized in 2007, which already created a survival bias, as only those that were still operating in year 2007 were investigated. It could be that we have missed a relevant part of installations that have already run out business during this time.

Also, installations that have started after 2005 but are running in 2007 would be omitted from our analysis, as we wouldn't recognise any workers working in these at the end of year 2004.

The control group of this set-up is somewhat problematic as different sectors are represented at different levels in control and treatment groups. Therefore, external influences for the manufacturing sector apart from EU ETS may not be fully reflected to the control group. For example, the paper industry is heavily represented in the treatment group and less so in the control group. Changes in the demand for paper products therefore influences outcomes of the treatment group and these changes are not fully internalized in the development of the control group.

The validity of the difference-in-differences comes from the assumption that the trend of the outcome variable would have been similar in treatment and control groups without the treatment. (Marin, Marino, Pellegrin, 2018). Therefore, we should be able to show, that the trend in outcome variable earnings developed similarly before the treatment between the two groups. Ideally, we should have information of the plants, their productivity, revenue, but as these are company-level information, we can't compare them.

Because of these reasons the results should be read with care and taken only as indicative starting point for further investigation for the effect of the policy on employment and earnings.

# 7 CONCLUSIONS

## 7.1 Main conclusions

It seems that the earnings of employees in the ETS-regulated installations were almost EUR 5 000 per year higher compared to the earnings of employees in non-regulated installation in same industries before the policy started. The difference has declined after the policy started on average by EUR 2 875 per year. The decline seems to arise from lower employment level, which have significantly decreased by more than 4 percent units after year 2010 compared to the controls which translates into 7 % decrease in employment.

The earnings of those who remain employed in the treatment group has remained higher compared to controls. The earnings of those who remained employed had a negative treatment effect of EUR 2 300 right after the policy started, probably reflecting the uncertainty around the costs of the policy. Apart from that year we couldn’t recognise treatment effect for the earnings of employed.

Whether the decline in earnings development is driven from the policy or from the other changes in the industries under investigation is not fully excluded from this analysis, as the sectors are represented by different proportions in the control group.

The result is similar as what Wagner, Muûls, Martin & Colmer (2014) found at installation-level in France, where employment decreased by 7 % in the phase II, but higher what Marin, Marino & Pellegrin (2018) found at company-level analysis.

We have studied the effect at installation-level, which makes the results more precise as the policy is determined at installation-level. Our set-up also differs from many others as we have followed the individuals.

## 7.2 Practical implications of the results

Out of the three hypothesis we had, it seems that the lower employment rate indicates that the pollution haven hypothesis holds. It could be that these jobs are lost due to reduction in production or that companies have relocated. As the policy have been able to reach its emission reduction targets and it seems that at EU-level the emissions of consumption have also reduced accordingly, it makes sense that the policy imposes also some trade-offs. In the light of these results, the trade-off seems to be the unemployed workers. A truly causal interference would need further investigation.

## 7.3 Suggestions for further research

The challenge of the ex-post evaluation of the effects of the regulation is to find out a causal relation between the policy and the changes in the outcome variables. Ideally, we would like to compare EU ETS firms to non-EU ETS firms facing similar demand, have similar resources, having same input prices and function under same regulation apart from EU ETS. As this is not possible, we can try to exploit the implementation of the policy, that EU ETS was designed to include only large installations. For example, steel plants with production capacity of 2.5 tonnes per hour are included, but plants with lower capacities are not. (Calel et al. 2017). As maximum capacity is somewhat fixed character of existing technology, it could be that plants around the threshold in the same sectors are to large extent similar to those below the threshold, or at least they don't systematically differ. For such analysis the data should include information of the maximum capacities to be able create a treatment and control groups around the threshold. Then it would be important to look at the distribution of installations around the threshold and investigate whether the avoidance of the policy would have changed the distribution. A problem with this approach could be that the number of installations around the threshold is too small for statistical interpretation.

# 8 REFERENCES

## 8.1 Data

Energy use in manufacturing, produced by Statistics Finland. Information of the data available online:
http://www.stat.fi/meta/til/tene_en.html

Finnish Longitudinal Employer–Employee Data, produced by Statistics Finland.

Information of the data available online:

https://www.stat.fi/tup/mikroaineistot/aineistot_en.html

https://www.stat.fi/tup/mikroaineistot/me_kuvaus_henkilo_en.pdf

## 8.2 Literature references


Calel, R. 2018, Adopt or innovate: Understanding technological responses to cap-and-trade.

Calel, R., Dechezlepêrtre, A., Mohnen, M. & Venmans, F. 2017, The competitiveness effects of the European Emission Trading System, FAERE Conference 2017 in Nancy, France, 12.9.2017.

Calel, R. & Dechezlepretre, A. 2016, Environmental policy and directed technological change: evidence from the European carbon market, Review of economics and statistics, vol. 98, no. 1, pp. 173-191.

Fabra, N. & Reguant, M. 2014, Pass-Through of Emissions Costs in Electricity Markets, American Economic Review, vol. 104, no. 9, pp. 2872-2899.

Ganapati, S., Shapiro, J.S. & Walker, R. 2016, Energy Cost Pass-Through in US Manufacturing: Estimates and Implications for Carbon Taxes.

Heindl, P. 2017, The impact of administrative transaction costs in the EU emissions trading system, Climate Policy, vol. 17, no. 3, pp. 314-329.

Joltreau, E. & Sommerfeld, K. 2019, Why does emissions trading under the EU Emissions Trading System (ETS) not affect firms' competitiveness? Empirical findings from the literature, Climate Policy, vol. 19, no. 4, pp. 453-471.

Lyubich, E., Shapiro, J.S. & Walker, R. 2018, Regulating Mismeasured Pollution: Implications of Firm Heterogeneity for Environmental Policy, AEA Papers and Proceedings, vol. 108, pp. 136-142.

Marin, G., Marino, M. & Pellegrin, C. 2018, The impact of the European Emission Trading Scheme on multiple measures of economic performance, Environmental and resource economics, vol. 71, no. 2, pp. 551-582.

Martin, R., Muûls, M. & Wagner, U.J. 2016, The impact of the EU ETS on regulated firms: what is the evidence after ten years?, Review of Environmental Economics and Policy, vol. 10, no. 1, pp. 129-148.

McCaffrey, D. F., Lockwood, J. R., Mihaly, K., Sass, T. R. 2012, A review of Stata commands for fixed-effects estimation in normal linear models, Stata Journal, vol. 12, no. 3, pp. 406-432(27), url http://www.stata-journal.com/article.html?article=st0267

Porter, M.E. & van der Linde, C. 1995, Toward a New Conception of the Environment-Competitiveness Relationship, The Journal of Economic Perspectives, vol. 9, no. 4, pp. 97-118.

Sijm, J., Chen, Y., & Hobbs, B. F. (2009, June). The impact of power market structure on the pass-through of CO2 emissions trading costs to electricity prices - a theoretical approach. In EAERE2009 conference (Vol. 2427).

Wagner, U.J., Muûls, M., Martin, R. & Colmer, J. 2014, The causal effects of the European Union Emissions Trading Scheme: evidence from French manufacturing plants, Fifth World Congress of Environmental and Resources Economists, Instanbul, Turkey.

Weyl, E.G. & Fabinger, M. 2013, Pass-Through as an Economic Tool: Principles of Incidence under Imperfect Competition, Journal of Political Economy, vol. 121, no. 3, pp. 528-583.

## 8.3 Online references

Chandreyee and Velten (2014): "The EU Emissions Trading System: Regulating the Environment in the EU". Climate Policy Info Hub, 13.05.2014. Online available at: http://climatepolicyinfohub.eu/eu-emissions-trading-system-introduction (referred 06.03.2019)

European Commission, EU ETS handbook 2015. Available online at: https://ec.europa.eu/clima/sites/clima/files/docs/ets_handbook_en.pdf (referred 06.03.2019)

European Commision, market stability reserve. Available online at: https://ec.europa.eu/clima/policies/ets/reform_fi (referred 04.10.2019)

European Commision, national allocation caps. Available online at: https://ec.europa.eu/clima/policies/ets/pre2013/nap_fi (referred 04.10.2019)

European Commission, revision for phase 4. Available online at: https://ec.europa.eu/clima/policies/ets/revision_fi (referred 04.10.2019)

European Commission, Ex-post investigation of cost pass-through in the EU ETS, EU publications (2015). Available online at: https://publications.europa.eu/en/publication-detail/-/publication/b89a0ad0-9275-11e5-983e-01aa75ed71a1 (referred 14.10.2019)

Finnish Energy Authority, information of verified emissions. Available online at: https://energiavirasto.fi/paastokaupan-julkaisut (referred 03.10.2019)

Finnish Energy Authority, revenue from auctions. Available online at: https://energiavirasto.fi/tiedote/-/asset_publisher/paastokaupan-huutokauppatulot-ennatyskorkealla-jatkossa-huutokaupattava-paastooikeusmaara-vahenee (referred 10.10.2019)

Hausfather, Zeke (2017), Carbon Brief. Online available: https://www.carbonbrief.org/mapped-worlds-largest-co2-importers-exporters (referred 28.02.2019)

Prahl Andreas, Hofmann Elena (2014): "European Climate Policy - History and State of Play". Climate Policy Info Hub, 14 November 2014. Online available at: http://climatepolicyinfohub.eu/european-climate-policy-history-and-state-play (referred 20.02.2019)

Sandberg, EUA price. Online available: https://sandbag.org.uk/carbon-price-viewer/ (referred 02.03.2020)

Updated from Peters, GP, Minx, JC, Weber, CL and Edenhofer, O 2011. Growth in emission transfers via international trade from 1990 to 2018. Proceedings of the National Academy of Sciences 108, 8903-8908. Online available at: http://www.pnas.org/content/108/21/8903.abstract

## 8.4 Referred legislations and EU reports

COM/2018/716 final: REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL EU and the Paris Climate Agreement: Taking stock of progress at Katowice COP (required under Article 21 of Regulation (EU) No 525/2013 of the European Parliament and of the Council of 21 May 2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC)

93/389/EEC**:** Council Decision of 24 June 1993 for a monitoring mechanism of Community CO2 and other greenhouse gas emissions

Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC

DECISION No 406/2009/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 April 2009 on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020

European Council, Presidency Conclusions - Brussels 8/9 March 2007, Council of the European Union, 7224/1/07, 2007

Decision (EU) 2015/1814 of the European Parliament and of the Council of 6 October 2015 concerning the establishment and operation of a market stability reserve for the Union greenhouse gas emission trading scheme and amending Directive 2003/87/EC (Text with EEA relevance)